

A Semi-Monthly Technical Newspaper

Metallurgical & Chemical Engineering

Volume XIV,

Number 8

April 15, 1916

McGraw Publishing Co., Inc.

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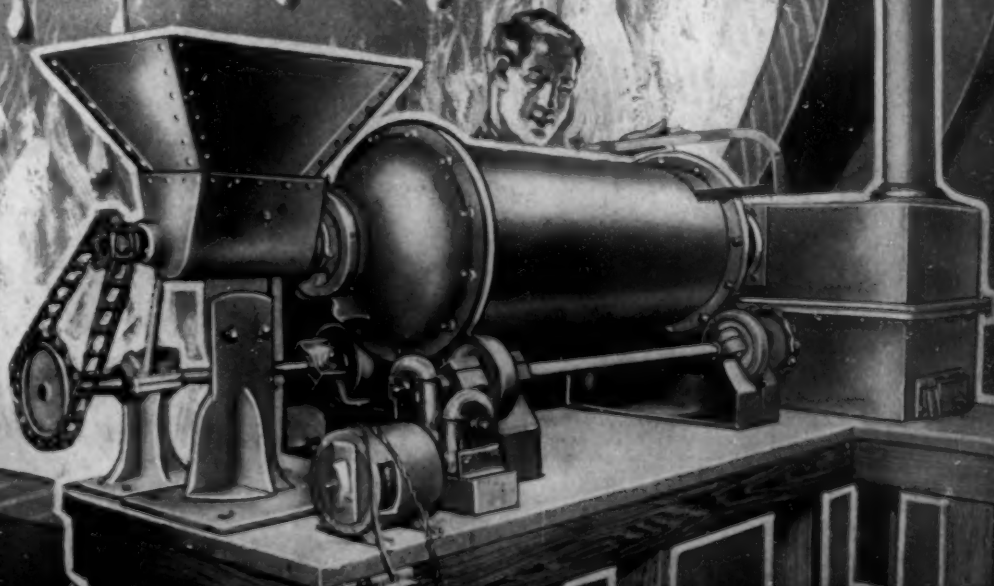
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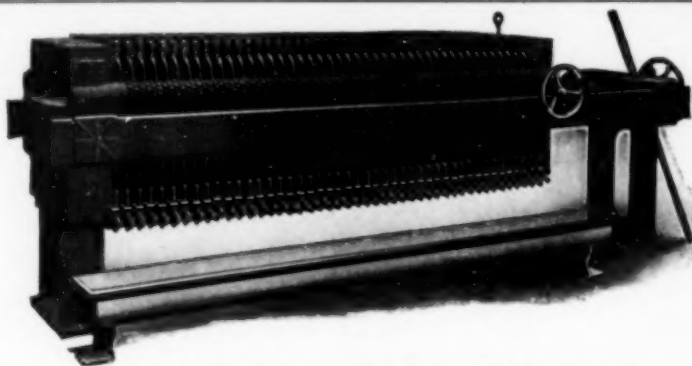
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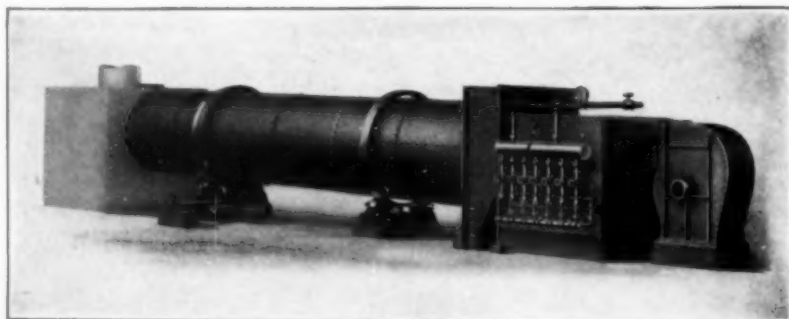
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Metallurgical and Chemical Engineering

A Consolidation of
ELECTROCHEMICAL AND METALLURGICAL INDUSTRY and IRON AND STEEL MAGAZINE

Vol. XIV

NEW YORK, APRIL 15, 1916

No. 8

PUBLISHED SEMI-MONTHLY ON THE FIRST AND FIFTEENTH
OF EACH MONTH BY THE

McGRAW PUBLISHING COMPANY, INC.

JAMES H. McGRAW, President.
A. E. CLIFFORD, Secretary. JOHN T. DeMOTT, Treasurer
239 West 39th St., New York.
TELEPHONE, 4700 BRYANT. CABLE ADDRESS, METCHAM, NEW YORK.
ROCKY MOUNTAIN OFFICE.....421 Boston Bldg., Denver, Col.
PACIFIC COAST OFFICE.....502 Rialto Bldg., San Francisco, Cal.
CHICAGO OFFICE.....Old Colony Building
CLEVELAND OFFICE.....Leader News Building
PHILADELPHIA OFFICE.....Real Estate Trust Building
LONDON OFFICE.....Hastings House, Norfolk St., Strand

E. F. ROEBER, PH.D., Editor.
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J. MALCOLM MUIR, Manager.

Yearly subscription price for United States, Mexico and
United States dependencies, \$3.00; all other countries, \$4.00.

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Entered as Second-Class Matter at the Post Office at New York,
N. Y., under the Act of Congress, March 3, 1879.

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One Function of Scientific and Engineering Societies in Democracy

Within the next two weeks the two largest national chemical societies of this country will hold their spring meetings. The American Chemical Society will meet at Urbana-Champaign in connection with the dedication of the new Chemistry Building of the University of Illinois. The American Electrochemical Society will meet a week later at Washington, D. C. Really remarkable programs have been arranged for both meetings—truly representative of the aims and spirit of the two societies. That both meetings will be highly successful there can be no doubt. However, as the full report of both conventions will appear in our next issue, we will not prophesy, but may be permitted instead to indulge, just for a moment, in a little reminiscence. The incident dates back some few years. It happened in the old Chemists' Club in New York—this will fix the date sufficiently.

He was a moderately able man and a fair chemist, engaged in manufacture. "This sort of thing," he said, referring to a chemical meeting which had just adjourned, "is all twaddle. There's nothing in it. Lot of wind bags get up and read papers and sputter, just to advertise themselves. Nobody tells anything that, so far as he is concerned, is of value. Why should he? In chemical industry, if you have a good thing you keep it to yourself. That's what you're there for. This idea of falling upon a man's neck and kissing him and talking to him like a school girl just because he is a competitor and is trying all the time to get your business away from you is piffle; arrant piffle!"

It may be that the gentleman's wife was not treating him very well, which oftentimes embitters the vision; it may be that he had a sour stomach, and it affected his disposition; perhaps he felt the need of a drink and the pill-wallah wouldn't let him take it, and then again, just as likely as not, this was what he really thought. He dropped out of sight a few years ago.

The trouble with him was that he was structurally too narrow-minded and too short-sighted to be a part of any movement that makes for progress. Let us consider what would happen to manufacturers now if they were to hold to secrecy in all things. We have had plenty of such experience. They joined in a lobby in Congress occasionally, but aside from that they were constant enemies of one another. Business was a battle and competitors were foes. The spy system was in full flower, and laborers were bribed to tell foolish secrets that a properly equipped research laboratory would soon prove to be the unprofitable enterprise that it is. It is still in thorough accord with the philosophy of the "practical" man who doesn't want any "theorists"

around him. With the craft and astuteness of the criminal injected into industry, the morale and standing of the men engaged in it degenerate. Industry, instead of building up a nation, which it can do, drags it down, which it can do even more easily.

The men who speak and read papers at meetings of the societies are not to be scorned for the very reason that they are the best men we have—the men of the widest knowledge, and who have achieved the greatest measures of success. The information that they give is of real and business value to them time and again.

The science of chemistry is the study of the ways of stuff, and these ways are too many and too different for any one man to learn. That is why it is better to draw information from a common source, to the end that each may make greater advances.

Two competitors may make the same product, and be in hot competition after the same markets, but if their raw materials are different, as they often are, the competition begins only after the product is made—between their sales departments.

The New York Section of the American Chemical Society has held three meetings (the last of which is reported elsewhere in this issue) to discuss the relations of the universities to industry, and the growing affinities between them were shown at each meeting. The distinctive mark of chemistry in America is that those engaged in pure research, on the one hand, and those engaged in industry on the other, have not gone their different ways separately, and have not developed those "class differences" which both the anarchists and the chemical world in many places acclaim and boast. "Science," said Dr. Levene of the Rockefeller Institute at the last meeting, "follows the economic development of a people." This is unprejudiced testimony, and is said with authority.

If chemical industry should take the narrow view of secrecy in this country and hold aloof from the learned societies of science, we can count upon its speedy failure with the same certainty that the wife of the drunkard can count on her husband's loss of his job.

Let us now make a little survey of the situation and see how matters stand. We live in a country of vast area, of miscellaneous population, of the greatest possible variation in density, and loosely governed. The energy available for constructive work in relation to government is largely exhausted in a quadriennial quarrel for the control of offices. The merit of the form is the avoidance of the danger of suppressing the development and growth of the individual. Its demerit is waste of energy and loss of direction. Its result is that government follows public opinion, and public opinion is not controlled—it drifts. Sometimes it drifts over dangerous shoals. Because of this drifting, industries have been built up artificially at one time and ruined, ruthlessly, at another. Human welfare has suffered and deteriorated as well as advanced under it. In so far as newspapers direct public opinion, there is no standard of editorial righteousness. That most dangerous of all practices, the appeal to wrath, which makes for

disorder and degeneracy of mind, is wholly unbridled. It is even encouraged—to develop circulation.

The source of the power that rules us as a nation, defends us, negotiates for us and looks ahead for us is public opinion. If that is wise we need not fear. If it is foolish we shall do well to fear.

Leaders of public opinion are not elected to perform that function. To lead public opinion is an entirely free scramble. The man on the soap box on the street corner is in the race for leadership. So is the President of the United States. So also is the able lawyer with a fat retainer in his pocket to forward the interest of the client who wants to work politics for his own benefit. He is far more dangerous than the man on the soap box. He does not appeal to the mob. He appeals to that enlightened stratum of society of which we hold ourselves to be a part. We are more easily molded under the Iago-like dexterity of the "distinguished publicist" with a legal fee in his pocket than are the men in the crowd around the soap box. They listen for a while and then go home and forget about it—mostly. We listen to the well-chosen remarks of the great lawyer, who is such an enemy to all that is evil (but with his secret fee in his pocket), and we go home with the conviction that "there is something in what he says." And we are right; there is a lot in what he says. It is so patriotic and intelligent that he wins us. The poison that we swallow along with all the patriotic and intelligent talk is not labeled. We take it along with the good. We think it good and, God help us! we like it. Of course, if we were informed, and had thought about his principal subject, which seemed so incidental in his remarks, he would have plead with us in vain. In the language of the street, we should have been "onto him." But if we are not informed, we are very likely to follow like sheep, and, indeed, if public opinion is to be called the voice of the mob, then we are a part of the mob.

Here may be found the great value of scientific societies in public affairs. The impression prevails that science does not strive to put facts out of their right relation to each other and so pervert the truth. The privileges of lawyers in this respect have cost them, as a body, a considerable measure of public confidence. The man of science, except when he offers expert testimony in court, is supposed to be peculiarly free from this defect. The findings of science are believed to have been reached with honest intent. President Herty of the American Chemical Society said at the last meeting of the New York Section, in regard to the Hill bill now before Congress to meet the dyestuff situation, that Southern cotton manufacturers had only asked concerning the bill, who had prepared it. They were told that it had been done by a special committee of the American Chemical Society. "Then," said they, after a hasty examination, "we are in favor of it." They were not fearful of politics back of it; they knew it was intelligently prepared, and they believed in the integrity of the men composing the committee.

In the haze of thought and the conflict of politics; in the chicanery of special interests, and the rumble of

the slow-moving and cranky steering gear of the ship of state, a new responsibility has devolved upon the great scientific and engineering societies. It is to tell the truth, from the standpoint of science, about those things which pertain to human welfare and progress in words that all may understand. Wherever science touches humanity there these learned societies may lead in public opinion. Their business is the spread of enlightenment.

Chemistry and Congress

Ordinarily the *Congressional Record* does not offer particularly interesting reading, especially to chemists. But if our readers will take the trouble to look up No. 86 of Vol. 53, covering the proceedings of March 31, they will be rewarded by finding in it two unusually able speeches, one by Representative Longworth for the Hill dyestuff bill, the other by Senator Underwood on the atmospheric nitrogen fixation problem. Yet it would be wrong to consider these speeches as isolated exceptions. They are signs of the times. On railroad trains, in clubs, in restaurants, wherever people come together, we hear them talk of chemistry.

While we are going to press we learn of the defeat in the Senate of the Lodge dyestuff-tariff amendment to the sugar bill, and Senator Underwood is stated to have been chiefly responsible for the defeat. As the official reports have not yet come to hand, we cannot believe that the same Senator Underwood who made that speech on the nitrogen problem two weeks ago, should have made unqualifiedly such statements on the dyestuff situation as he is reported to have made in some of the newspapers. It seems unbelievable that this should be the end of the dyestuff tariff fight in the present Congress. For the present we prefer to take it as part of the political game. But the situation needs watching. The time is critical.

Coke Ovens as Gas Producers

About eight years ago some amusement was caused by the announcement that blast furnaces were being blown in at the Gary plant of the United States Steel Corporation, not because pig iron was needed, but because the gas was required. The first Gary furnace was blown in Dec. 21, 1908, the second Dec. 29, and the third Jan. 26, 1909, while steel was not made until Feb. 3. The first furnaces were operated as gas producers rather than as pig-iron producers.

Now we have a large retort coke plant that is to be located as a gas producer rather than as a coke producer. While the coke output will, of course, be as valuable and useful as under other circumstances, it is understood that the location and size of the Clairton plant to be built by the Steel Corporation are determined largely by the gas requirements of the Corporation's Pittsburgh district steel works, now that serious decreases in the natural gas supply in the next couple of years must be faced. Except for certain merchant coke plants, all retort coke oven plants have been adjusted in size to the requirements of the blast furnaces at which they were built. This

policy is to be departed from at Clairton, where there are three blast furnaces, while the coke plant to be built is to comprise 640 retorts and eventually 1300. The appropriation under which construction work will shortly be started covers 200 ovens. The output of 1300 retort ovens should be in the neighborhood of 5,000,000 tons of coke annually, about ten times the requirements of the three Clairton blast furnaces. At 4000 cu. ft. of gas per ton of coke the gas output would be 20,000,000 M cu. ft. annually. The country's natural gas production has lately been running at a trifle less than 600,000,000 M cu. ft., so that the Clairton gas, though of relatively low calorific value, will be a distinct item.

Coal Refining

As a problem in chemical engineering the refining of coal offers some attractive possibilities. Coal is one of the few mineral products used largely in the raw state, despite the fact that the wastefulness of the process has long been recognized. Like petroleum, which no one thinks of using to any extent in the raw state, coal is a complex substance susceptible of separation into many valuable products, with the fixed carbon left in improved form for fuel.

A Western problem of this type is the refining of lignite—a coal high in moisture and volatile matter, and wholly unsuited to efficient consumption in the raw state. Bulletin 89 of the U. S. Bureau of Mines is devoted to the efficient use of lignite, recording studies made in North Dakota; and elsewhere we have referred to extensive work being done in Colorado. If magnitude is a factor in making a proposition attractive, this one must be expressed in superlative terms, for the bulletin mentioned conveys the information that in North Dakota alone the deposits cover 32,000 square miles and are "capable of producing in all several hundred billions of tons of lignite."

Gas, ammonia and tar are the products of the destructive distillation of lignite, and the briquetted residue is in far better shape, physically and chemically, for use as fuel than was the original coal. The tar obtained is an important product, for from it may be fractionated light and heavy oils and pitch. In the Colorado work an effort is being made to introduce some of these distillates as flotation oils. It is claimed that since they are fractions distilled at definite temperatures, uniformity can be maintained in the products, and that a suitable combination once determined can be duplicated without difficulty. This would be an important consummation, for one of the reported difficulties in flotation work has been the lack of uniformity in successive lots of oil bought.

Coal refining offers an opportunity for industrial development in the West, for lignites are abundant in North Dakota, Montana, Wyoming, Colorado, Texas and other Western States. The development will be slow, for outlets must be found for the products and related new industries must be established. Pioneer work has commenced, however, and the results will indicate how rapid an expansion can be anticipated.

Readers' Views and Comments

Cheap Power from Central Stations for Electrochemical Work—Possibilities of the Pacific Northwest

To the Editor of Metallurgical & Chemical Engineering

SIR:—In your issue of March 15, in a letter from "A. C." of Brooklyn, N. Y., he states: "Finally, it ought to be possible to buy current from some of the great central station companies in our larger cities. Prices approximating $\frac{1}{2}$ cent per kilowatt-hour have been rumored. Of course, such a rate would only apply to those hours of the day when the regular light and power load is unusually light."

I have noted in the technical papers from time to time recently similar statements to the effect that power at one-half cent per kilowatt-hour should be available.

In this connection, I wish to call attention to the rates of the Puget Sound Traction, Light & Power Company, operating in Seattle and the Puget Sound territory. Our water power plants now have an installed capacity of 74,000 horsepower, supplemented by steam relays with capacity of 34,000 horsepower. Our regular commercial power rates for loads in excess of 101 horsepower for continuous use is $\frac{1}{2}$ cent per kilowatt-hour. To electrochemical or electrometallurgical processes, or other concerns using large blocks of power continuously we can quote a very materially lower rate and are in the field for such business.

We have in contemplation two additional waterpower developments which will be made as quickly as the market demands warrant, where from 75,000 to 150,000 additional horsepower can be obtained, depending upon the method of development decided upon. With the output of the Niagara Falls plants practically all sold, it is believed that the Pacific Northwest offers better opportunities for low cost electric power than any other part of the United States to-day.

It is realized that the cost of electric power in many of the industries is not the dominating feature, but in the electrochemical and metallurgical field it is known that the percentage of power cost to the final cost of the manufactured article is relatively high, and for this reason it is believed that the extremely low rates available here should be of much interest.

W. E. HERRING.

Puget Sound Traction, Light & Power Co., Seattle, Wash.

"All Around the Edges"

To the Editor of Metallurgical & Chemical Engineering

SIR:—At the risk of your already knowing the story of how "Shorty" McCabe met his nephews coming from abroad, I am repeating it here, since it seems to express the attitude of some in the East as to the present hydroelectric power situation in the United States.

Shorty was a New Yorker; had never been further West than Albany—as a fact thought anything beyond the State capitol was the "wild and wooly West." Broadway, Fifth Avenue and Forty-second Street were his world.

One day Shorty met his nephews coming in on a trans-Atlantic steamer.

The young fellows came off the gang plank, full of enthusiasm, pleased to set their feet on terra firma again. To be sure that they by chance had not got on

the wrong steamer in Liverpool, they asked Shorty, after greeting him: "Is this United States?"

"No, indeed," replied Shorty, "this is not United States; this is little, old New York."

The nephews, much puzzled, asked, "Where, then, is United States?" To which they received the true and typical reply, "Why, United States is all around the edges."

Is there not some similarity in Shorty's attitude regarding New York and the rest of the country to that taken at present by many of the electrochemical power consumers and others in the East, as to the hydroelectric powers of United States.

From reports of various meetings held in the East I notice a howl and clamor regarding the lack of hydroelectric power, and the claimed impossibility of obtaining same, due to the attitude of the government.

To be sure the government may justly, or unjustly, put restrictions on the development of power at Niagara Falls. But there is still something "all around the edges," containing large quantities of cheap available hydroelectric power, located either inland on railway, or on tidewater.

It is worth remembering in this connection, that 40 per cent of all the hydroelectric power of the United States is located west of the Rockies, and everybody familiar with the situation there can name a number of power sites that are awaiting development, and are besides cheap developments, with water assured for power 365 days of the year.

Among the most noted ones at present, is the Speel River project in Alaska, where 100,000 horsepower, located on tidewater, are awaiting development. This power is situated in a manner identical with some of the famous Norwegian developments, like the one at Tysso, near Odda.

The Columbia River development at The Dalles, is another project on tidewater. Close to a million horsepower can be obtained there, the most of which is available twelve months of the year. Here power has been offered in large blocks at a price less than \$10 per horsepower-year.

The Great Western Power Company, the largest individual power producer on the Pacific Coast at the present time, has some 100,000 horsepower already developed, and is prepared to enter into contracts with power consumers for 500,000 horsepower more, at low rates, either at the power sites, on the Western Pacific Railroad, or on tidewater on San Francisco Bay.

The poor, abused company, mentioned by one of the speakers at Niagara Falls, which had to go to Europe for additional power, due to dearth of same in the United States, could not have had its ear close to the ground? Perhaps the cause in reality was another. Wasn't it a question of waging a war in the enemies' country, and not lack of power in United States?

The government's attitude may not always be what seems the wisest in regard to Niagara Falls, but in spite of that, there is still power "all around the edges," aggregating about 1,500,000 horsepower, if only the three above mentioned developments are considered, and these, compared with Niagara Falls, make a good showing.

The industrial preparedness of the United States is indeed important, but how can this be even launched as a valid argument in favor of increasing the power developments, legitimate as this may be, at Niagara Falls,

with only a narrow strip of water between us and a potential enemy.

Unfortunately we cannot prescribe with whom we may have a scrap. If with England and Canada, which I hope will never occur, what would a few shots from a cannon do to our industrial preparedness at Niagara Falls?

Few places in the world are as favorably located as Niagara Falls for electrochemical industries, but I feel equally certain that some places "around the edges" will in the next decade develop, in a manner that may to some extent rival the electrochemical supremacy of Niagara Falls.

J. W. BECKMAN.

San Francisco, Cal.

So Much Fire and So Little Light

To the Editor of Metallurgical & Chemical Engineering

SIR:—The *New Republic* is a journal of opinion and so far as I am aware it has no interests to conciliate. The editors of it are not pressed for time and there is no scramble in its pleasant offices over in the Chelsea district of New York to get a beat on news. Its articles are wrought with consummate literary craftsmanship, and the sentences that compose them follow one another in such urbane and graceful procession as to give the lover of English a sense of pleasurable envy, whether he agrees or not. In considering a book called *The Pillar of Fire* by Seymour Deming, a very radical work and full of prophecy of the Kingdom of Wrath unless we mend our ways. Mr. Randolph Bourne says: "Mr. Deming moves you but he leaves you in the end more entertained than persuaded. His prophetic fire is so much fire and so little light." The merits of the book are then set forth but the fatal words are said: "So much fire and so little light." And it fitly describes the labor situation to-day. The interesting point is developed in the review that the radical of to-day, as he enters into constructive thought, is speedily denounced as a snob and told to "go down into the labor unions and socialist locals and learn of the workingmen. Let him touch the great heart of the people. . . . Only by humbly working up through the actual labor movement will the young radical learn his job."

Well, time and again the young radical does go down to the labor unions and socialist locals—and it is right and proper that he should—but when he gets there he finds his welcome to be gaged according to his acceptance of every doctrine laid down; the bad with the good, the hate with the sympathy, and the support of every strike as soon as violence begins. The one thing he must not be is "intellectual." Everything is a fight, everything is a struggle, and the way to win is to swat and swat hard. Trouble with those highbrows is, they're floppy. First they agree and then when something comes up they don't agree and they make a fuss. They're no good. This is often the union point of view.

Then the young radical, unless he has more character than most men is likely to be swept along in the stream of hate, and he grows to lean more and more toward dynamite and away from law and order.

Now we live in a world of misfits and we cannot hope that society will do much more than stagger along under the great burden that it has to carry until we find a better way of fitting jobs to men than we know of to-day. But we venture the assertion that what holds us back from progress and begets the outbursts of disorder is feeble-mindedness more than anything else.

We are all feeble-minded in one way or another. The aesthetic feeble-mindedness of manufacturers is proven by their works, the ugliness and shoddy look of factories, the dirt and general befoulment that factories produce,

which the enrichment of art dealers by those who have prospered in manufacture and even the maintenance of private picture galleries do not controvert. The social feeble-mindedness displayed by the introduction of workmen who, for lack of proficiency in English are unable to defend themselves, to take the places of competent men who may have struck for good and sufficient reasons, is too evident to need elucidation. Some few men are so gifted that they seem to be feeble-minded only in regard to *vers libre* or cubist painting, but they are rare birds indeed. What mortal has a right to think that he can build a factory, ruin the health and the hope of his operatives, and at the same time expect to have his works endure? He would not do this unless that portion of his equipment which functions as sympathy were either atrophied or congenitally lacking. We who bear the odium of the radicals by being what they call "capitalistic" need not boast; there is plenty of feeble-mindedness among us.

Now come those that have begun to boast that they are the proletariat. How much of this defect of feeble-mindedness have they to carry along with them and support? They get all those who are not lucky enough to have somebody support them, except such as gravitate to the criminal class. When the father dies, in most cases there is not much left after the funeral expenses are paid. What happens to the boys and girls that are, as we say, "not very bright"? They look for work. Gradually, with the slight demands made upon the mind by a great deal of machinery, they become "hands" in manufacturing of one sort or another. If the boys are strong they may get a job in the mines when men are wanted. There are a great many such persons that have wit enough to keep at a job and can do, say, three-quarters of a man's work. They pay their dues and join the union. They draw the minimum wage for a day's work and perform three-quarters. That brings the standard down 25 per cent. Now, instead of bringing enlightenment to bear upon the situation employers have frequently brought craft and force. The three-quarter men do not know that they are limited in capacity, and their comrades stand by them. The sympathy between the three-quarter men and the whole men is greater than the sympathy between the whole men and the employers. Then comes trouble. The inadequates follow the vicious, and soon the strike vote is taken.

The only way to deal with the inadequates is to provide for them. There should be a place where a three-quarter man could do his three-quarters in a full day's time. Of course, he would have no opportunity for advancement. At the same time there should be a place where a 100 per cent man could do a full day's work at not much better wages but with a chance for extra pay and from which group the men for the higher positions should be drawn. This would sift out the vigorous from the inert, the capable from the incapable; it would separate the culls.

It should be no disgrace to be among the three-quarter men. Many of us would find ourselves in that gang if we had had no chances. It would not of necessity mean that the men were feeble-minded except as to that particular kind of work. Some of them might be rarely gifted in other respects and if an opportunity to use their talents could be found elsewhere, both employer and employees would be anxious to secure it for them. Advancement and authority, however, would only go to the whole men.

Could such an arrangement be made with the Western Federation of Miners? Certainly not. Or with a political body like the American Federation of Labor? Surely not, with politics all tangled up with it. It will require a new angle of vision; something, perhaps, like

what seems to be growing in Colorado. But think what it would do! The drag upon labor unions would be lifted; the three-quarter men would be provided for and constructive plans for increased output along with betterment of labor conditions could be undertaken with the whole men. The agitator with nothing but anger and disorder to offer would have less standing. The whole men, who would naturally lead, would have a higher average intelligence and while their demands might be more astutely drawn, they would be more reasonable in them. Many employers would have to be converted from their present ways and many others would do well to give up in despair rather than try to administer industrial affairs under enlightened conditions; but if we want to make advancement in industrial life in this country we must make up our minds to face enlightened conditions in the labor situation.

Modern machinery is not designed to develop latent intelligence among operatives. The great desideratum is to make a machine at once "simple to operate" and "fool proof." These are good qualities, but they do not exercise the brain or develop the general intelligence of the operative. That is a defect of merit. Machinery does not improve the quality of labor.

So long as organized labor is burdened with its great load of feeble-mindedness it is bound to protect its weaklings because they are not otherwise protected. We cannot call this attitude of mind either wrong or vicious or evil. And so long as this burden is upon labor it is unfair to expect it to close its eyes to the advocates of disorder or to engage in constructive work with the administrative force of great industries. So we must devise a means to give the man who can do things a chance to better himself while the burden of carrying the man who cannot do as much is lifted from his shoulders.

If this is accomplished the time may come when the administration of a corporation may invite representatives of their laborers to be present at annual meetings of stockholders to explain what provision is made for living conditions at the works and what remains to be done, as an offset to demands for more dividends. Then if stockholders still demand greater division of earnings in spite of an agreement between the administration and the labor force, they can take the consequences. But they are not likely to. Capital is not vicious, any more than is labor, in its original intent. But sometimes it is stupid, just as labor unions are sometimes stupid and in a dull, blind, unthinking way it wants to grow—like a cancer. A cancer doesn't care about doing any harm or about hurting anybody. It just minds its own business—and wants to grow. That is why it is so dangerous.

ELLWOOD HENDRICK.

NEW YORK CITY.

Program of Washington Meeting of American Electrochemical Society

The annual meeting of the American Electrochemical Society will be held at Washington, D. C., from Thursday to Saturday, April 27 to 29, 1916. Headquarters will be at the New Willard Hotel, Pennsylvania Avenue, Fourteenth and F Streets.

The American Institute of Electrical Engineers, which will hold a meeting on Wednesday, April 26, at the New Willard Hotel, has extended a cordial invitation to the members of the American Electrochemical Society to attend this meeting. Reciprocally, the members of the American Institute of Electrical Engineers are cordially invited to attend the sessions of the American Electrochemical Society, particularly those of Thursday, which have been arranged to be of particular interest to electrical engineers.

The American Electrochemical Society will hold three sessions on Thursday (morning, afternoon and evening) and two sessions on Friday (morning and evening), all of these at the New Willard Hotel, while a long morning session is scheduled for Saturday at the Bureau of Standards.

The program is so crowded with papers, symposiums and lectures that no social functions have been scheduled except the lunches on Thursday at the New Willard Hotel and on Saturday at the Bureau of Standards, and the excursion to Mount Vernon on Friday afternoon.

Wednesday, April 26, 1916.—Meeting of American Institute of Electrical Engineers, to which the members of the American Electrochemical Society have been cordially invited, at 2 p. m. and 8.15 p. m., at the New Willard Hotel. The program of the two sessions is as follows:

Address by President JOHN J. CARTY.

"Electrochemical Industries and their Interest in the Development of Water Power." By LAWRENCE ADDICKS.

"Water Power Development and the Food Problems." By H. S. CUSHMAN.

"Relation of Water Power to Increase Transportation." By L. B. STILLWELL.

"The Relation of Water Power to the National Defense." By W. R. WHITNEY.

"The Water Power Situation, Including Its Financial Aspects." By GANO DUNN.

Thursday, April 27, 1916; 9.30 A. M.—Annual business meeting of the American Electrochemical Society in the Red Room of the New Willard Hotel. (Reports of Board of Directors, announcement of annual election, miscellaneous business.)

Presidential address by the retiring president, LAWRENCE ADDICKS.

Symposium on co-operation in industrial research: LAWRENCE ADDICKS, the professional society; F. A. LIDBURY, the professional society; W. D. BANCROFT, the university; W. H. WALKER, the university; D. A. LYON, the Government; L. H. BAEKELAND, the corporation; W. R. WHITNEY, the corporation.

"The Detectors in Wireless Telegraphy." By W. D. BANCROFT.

"Hydrogen for Military Purposes." By E. D. ARDERY.

"Liquid Chlorine." By G. ORNSTEIN.

"Magnesium." By W. M. GROSVENOR.

12.30 P. M.—Luncheon in the New Willard Hotel.

2 P. M.—Meeting in Red Room of the New Willard Hotel.

Symposium on Niagara Falls Power and the American Industries:

"The Power Development." By I. R. EDMANDS.

"Electric Furnace Products." By F. J. TONE.

"The Chemical Industries." By A. H. HOOKER.

"The Nitrogen Question." By W. S. LANDIS.

Illustrated address, "Reclamation Service Water Power." By Director A. P. DAVIS, chief of the Reclamation Service.

"The Brittleness of Annealed Copper." By W. E. RUDER.

"Cobalt as an Element for Thermocouples." By G. L. KOWALKE.

"Electrical Resistance of Copper-Nickel Alloys." By F. M. SEBAST and G. L. GRAY.

"Faults in the Small Electric Arc Furnace."

"The Rennerfeldt Electric Arc Furnace." By G. H. VOM BAUR.

8.15 P. M.—Meeting in the Red Room of the New Willard Hotel.

Illustrated lecture by J. H. PIERCE, "Water Power Development for Electrochemical Purposes."

Friday, April 28, 1916; 9.30 A. M.—Meeting in the Red Room of the New Willard Hotel. The following papers will be read and discussed:

"The Passive State of Metals." By C. W. BENNETT and W. S. BURNHAM.

"Overvoltage." By C. W. BENNETT.

"Overvoltage and Monatomic Hydrogen." By W. D. BANCROFT.

"Depolarization by Electrical Waves." By W. D. BANCROFT.

"Electrode Surface Phenomena." By W. C. ARSEM.

"Contact Resistance of Metal Electrodes." By N. K. CHANEY.

"Contact Potentials and Electrochemical Potentials." By I. LANGMUIR.

1.45 P. M.—Steamboat leaves Washington for trip to Mount Vernon, returning by trolley car via Alexandria.

8.15 P. M.—Meeting in the Mezzanine Room, New Willard Hotel. The following papers will be read and discussed:

"Polarization in LeClanche Cells." By D. A. MACINNES.

"Electrolytic Formation of Perchlorate." By C. W. BENNETT and E. L. MACK.

"Unstable States in Arc and Glow." By W. G. CADY.

"Electric Arcs in Vapors and Gases at Low Pressures." By W. A. DARRAH.

"The Moore Tube for Color-Matching." By W. McF. MOORE.

"Corrosion and the Engineer." By W. H. WALKER.

"Effect of Rust Upon the Progress of Rust." By J. ASTON.

"Influence of Frequency of Current on Electrolytic Corrosion." By B. MCCOLLUM and G. H. AHLBORN.

Saturday, April 29, 1916; 9.45 A. M.—Meeting at the Bureau of Standards, Assembly Hall of the Electrical Building. The following papers will be read and discussed:

"Some Unsolved Problems of the Electroplater." By G. B. HOGABOOM.

"Nickel Plating." By F. C. MATHERS, E. H. STUART and E. G. STURDEVANT.

"Rapid Nickel Plating." By O. P. WATTS.

"Test of Tin Plating Baths." By F. C. MATHERS and B. W. COCKRUM.

"Use of Peptone in Tin Baths." By F. C. MATHERS.

"Addition Agents in Electrodepositing Silver from Silver Nitrate Solutions." By F. C. MATHERS and J. R. KNEBLER.

"Electrolytic Zinc." By W. R. INGALLS.

"Recent Progress in Electrolytic Irons." By O. W. STOREY.

1.30 P. M.—Luncheon will be served in the dining room of the Bureau of Standards.

Program of Meeting of American Chemical Society at the University of Illinois

The principal features of the program of the meeting of the American Chemical Society, to be held at the University of Illinois, Urbana-Champaign, Ill., from Tuesday to Friday, April 18 to 21, were given in our issue of April 1, page 358. Additional features are as follows:

The general session on the morning of Tuesday, April 18, 9.30 a. m. will be opened by speeches by Dr. W. A. NOYES, President EDMUND J. JAMES of University of Illinois, and President CHARLES H. HERTY of the American Chemical Society, whereupon the following addresses will be made:

L. H. SMITH, "The Composition of Corn as Affected by Nineteen Generations of Seed Selection."

ARTHUR H. THOMAS, "The Manufacture of Chemical Apparatus in the United States."

RAYMOND F. BACON, "The War and the American Chemical Industry."

G. H. A. CLOWES, "On the Influence Exerted by Electrolytes on the Equilibrium of Emulsions, Jellies, and Living Cells."

JOHN JOHNSTON, "Some Effects of High Pressure."

The same evening at 9 p. m., a "Get-Acquainted" Smoker will be held in the gymnasium annex.

On Wednesday, 2 p. m., the new Chemistry Building of the University of Illinois, will be dedicated, Governor EDWARD F. DUNNE of Illinois, presiding. Addresses will be made by President EDMUND J. JAMES of the University, Dr. ALEXANDER SMITH and Dr. W. R. WHITNEY.

In the evening of Wednesday a subscription dinner will be held at the Masonic Temple, Champaign.

Divisional meetings will be held on Wednesday, 9 a. m., Thursday, 9 a. m. and 2.30 p. m. Local excursions will take place on Tuesday and Thursday, 2 p. m., and the excursion to Danville on Friday, 7.30 a. m.

For Thursday evening, 8 p. m., two public lectures are scheduled by Dr. CHARLES L. PARSONS on the production of radium and by Dr. CURTIS F. BURNHAM on the use of radium in treatment of cancer.

An exhibition of chemical products and apparatus will be held in the basement of the new Chemistry



DIAGRAM OF EXHIBITS

Building. A floor plan of the exhibition is given in the adjoining diagram. The numbers in the sketch refer to the following exhibitors:

1. Scientific Materials Company; 2. METALLURGICAL & CHEMICAL ENGINEERING; 3. General Electric Company, Research Department; 4. Macbeth-Evans Glass Company; 5. Elmer & Amend; 6. Libbey Glass Company; 7. Standard Calorimeter Company; 8. Lenz & Naumann; 9. Durriron Castings Company; 10. Central Scientific Company; 11. Elyria Enameled Products Company; 12. U. S. Bottlers' Machinery Company; 13. Sweetland Filter Press Company; 14. National Lead Company; 15. Laboratory Supply Company; 16. National Carbon Company; 17. Sarco Company; 18. Mitchell Lime Company; 19. Emil E. Lungwitz; 21. Sowers Manufacturing Company; 22. Schaeffer & Budenberg Manufacturing Company; 23. Abbe Engineering Company; 24. Thwing Instrument Company; 25. Dearborn Chemical Company; 26. Edison Storage Battery Company; 26. John Wiley & Sons; 27. Henry Holt & Co.; 28. McGraw-Hill Book Company; 29. Longmans, Green & Co.; 30. F. Blakiston's Son & Co.; 31. Celluloid Zapon Company; 33. Thermal Syndicate; 34. E. R. Squibb & Sons; 35. Fairview Fluorspar & Lead Company; 35a. McIntosh Stereopticon Company; 35b. J. P. Devine Company; 36. Toch Bros.; 37. Braun Corporation; 38. Norton Company; 38a. Herold China & Pottery Company; 39. Pfaunder Company; 40. Permutit Company; 40a. Sharples Specialty Company; 40a. Armour Ammonia Works; 41. Schutte & Koerting Co.; 42. American Coal & Byproducts Company; 43. Chattanooga Chemical Co.; 43. U. S. Metals Refining Company; 44. Manhattan Rubber Co.; 45. Pato Co.; 46. Walrus Mfg. Co.; and Leeds & Northrup Company in Research Laboratories, Physical Chemistry, Room 165.

The number of papers to be presented in the sessions of the different Divisions is little less than 300, as follows: Agricultural and Food Chemistry, 22 papers; Biological Chemistry, 76; Industrial Chemists and Chemical Engineers, 26; Organic Chemistry, 53; Water, Sewage and Sanitation, 28; Physical and Inorganic Chemistry, 62; Pharmaceutical Chemistry, 15 papers.

The chairman of the executive committee at Urbana-Champaign, is Prof. Edward Bartow.

Notes on Metallurgical and Chemical Engineering in Great Britain

(By our London Correspondent)

Industrial Coordination

In modern slang we are now going "all out" over co-ordination. There are governing bodies in Great Britain possessing powers of industrial control more absolute than anything conferred by medieval Parliament, and more dictatorial in their powers than any of the old trade guilds. The fiat goes forth to Messrs. So and So "you shall make such and such things," and Messrs. So and So conform. Again Messrs. Somebody-else inquire "may we execute this order for export, or that order for internal trade?" The reply "Yes" or "No" as the case may be is final.

This state of affairs has its philosophic interest no less than its future historic value or its immediate national purpose. We are out to overcome Prussianism. Your correspondent said in a previous letter that even in overcoming, success would leave us tinged with much that was Prussian. To-day he is tempted to go further and say that it is only in emulating Prussian co-ordination that we shall win through in a reasonable time. We are only repeating old precedents. The Christianity which overcame Paganism was overlaid with much that was Pagan. Again Paganism in putting forward Mithraism as its last word in those early centuries was consciously or unconsciously becoming the exponent of a monotheistic creed with distinct similarities to parts of the Christian doctrines. Lest any readers of this (after and if it has escaped the editorial blue pencil) wonder why your correspondent should soliloquize over his memories of the volumes about the decline and fall of another empire—volumes which he cannot get hold of at the moment—your correspondent can only plead keen interest which the abstract problems raise.

Among other things from which we have suffered has been that of a neglect of the historic sense. Otherwise we should never have had the spectacle of a British statesman declaiming in the House of Commons less than a decade ago that he did not believe that there were such things as inevitable wars. To-day it is not a very far cry from the orator in the Senate with his "Carthago delenda est" to a right honorable gentleman at Westminster observing that "he will stick at nothing" to win.

Well, in the co-ordination of industry—call it mobilization of industry if you will—we have out-Heroded Herod. We have done more in twelve months than the most pedantic Fabian would have conceived feasible in one hundred times as long in period. The miracle is that it works and works astonishingly well. Many people talk amiably banal stuff about going back to the old régime after peace comes. Of course, we shall not keep it up in its entirety, but we shall have given the doctrinaire Socialist most amazing precedents, and we shall have realized that national life is not a mere string of negative Commandments. The "Thou Shalts" will be more numerous than its "Thou Shalt Nots."

Of course, the trend of the future will have its bias toward bureaucratic control, but so long as the bureaucracy is honest and alert and intelligently virile, there are many worse conceptions than a capable bureaucracy.

Electrolytic Hypochlorites

It is now twenty years since your correspondent was in New York City and then concerned with the manufacture of hypochlorite of sodium from sea-water under A. E. Woolfe. Having subsequently been engaged in the manufacture and application of electrolytically produced solutions of hypochlorite to domestic disinfection,

sewage sterilization, and the bleaching of cellulose materials in England, it was of much interest to see in the *Times* the other day that the hospital ship *Aquitania* was fitted with an electrolyzer producing liquids of two grams of available chlorine per liter strength. The technical details are scanty in the extreme—apparently the cell has a large number of electrodes in series as it is used on a 110-volt circuit. To any one who knows what the germicidal value of one part per million of available chlorine in a drinking water or what from 5 to 8 parts per million will do in sterilizing sewage effluents, the enthusiastic praise of the medical staff of the *Aquitania* is no surprise.

Nothing is said in the newspaper accounts of the electrochemical efficiency or stability of the final product. The concentration in available chlorine is low, much lower indeed than that of Woolfe's solution which ran from 3½ to 5 grams of available chlorine per liter. Later in England the present writer found that stable solutions of 7 to 10 grams were commercially practical products, and that 12 to 15 grams solutions were practicable from the Crawford electrolyzer, but not commercial. It is rather a temptation now that one is middle-aged to review the last two decades of the electrolytic chlorine industry in England. On the one hand, we have the splendid financial success of the Castner Kellner process—against this there are other processes which yielded gaseous chlorine and sodium hydrate which have disappeared. There was, too, the meteoric career of the Commercial Development Company, with the patent litigation which wiped up the Rhodium cell.

Of the hypochlorites themselves their only field can lie in cases where the solution can be made and used on the spot. Otherwise their low concentration renders them economically impossible to transport. It is interesting to recall the types of cells one has known intimately—the Hermite, the Crawford, the Oxychloride, and the now moribund "Meridionizer." In all-round utility the Crawford was probably the best—but platinum anodes with platinum at present prices are unthinkable. Then we used to pay £4 per ounce—now, well it is doubtful whether at £30 per ounce anyone could secure enough platinum in Great Britain for cells having an aggregate input of say 25 kw.

Corrosion

Probably no more interesting discussion on corrosion has ever been held in England than that which took place at the Faraday Society at its meeting early in December. Sir ROBERT HADFIELD opened the proceedings by a communication on the "Corrosion of Steel Alloys." The world's iron losses by corrosion, he stated, in dwelling upon the importance of the subject, was estimated at hundreds of thousands of tons annually. Yet some Egyptian iron; e.g., a hatchet 2500 years old probably, discovered by Dr. Flinders Petrie in dry sand, he believed, was still apparently in its original condition. But nickel steels, supposed to be non-corrosive, rusted very badly when once corrosion set in, though high nickel steels were more resistant. He had lately again been engaged, together with Dr. N. Friend, in investigating the corrosion of special steels. Some chromium steels (about 11 per cent of Cr, 1 per cent of C), which he had made in 1892, were fairly non-corrosive, and still free from rust, and gave remarkable results in mechanical tests. Sir Robert had also analyzed and tested the "stainless steel for cutlery, and had made some himself, which contained from 10 to 12 per cent of Cr and about 0.3 or 0.4 per cent of C, while the commercial steels contained in addition 0.45 per cent of cobalt and little manganese and silicon; these steels had a remarkable hardness even before being hammered, and elongations

of up to 32.5 per cent. The material would probably require great care in forging and rolling, but an opening would, no doubt, be found for it."

Mr. LESLIE AITCHISON, M. Met., of Sheffield, described a further series of "Experiments on the Influence of Composition upon the Corrosion of Steel," dealing with pure iron and carbon steels and special steels containing tungsten, nickel, cobalt, manganese, chromium, vanadium, or copper. The special steels were studied in two series. In the one series the tungsten percentage rose from 2.36 to 26.3 (about 0.7 per cent of C), the vanadium from 0.7 to 12.45 (carbon 0.6 to 1.1 per cent), the cobalt from 2.68 to 20.85 (carbon again about 0.7 per cent), the chromium from 1 to 23.7 (0.85 per cent of C). In the second series both the fourth metal and the carbon varied, but the former only slightly, the tungsten steels containing about 3 per cent of W, the vanadium steels about 0.2 per cent of V, the chromium about 2 per cent of Cr, the nickel steels about 3 per cent of Ni, the manganese steels about 1 per cent of manganese, the copper steels from 0.45 to 4.78 per cent of Cu, however. In this last series the percentages of the third metal were not high as a rule, therefore, and the average percentage was selected on the strength of the previous experiments. All the specimens were immersed for many days (seventy-seven generally) in 3 per cent sodium chloride solution, in sulphuric acid of 1 per cent and of 10 per cent, and in tap water, the liquids being renewed seven times, and tested also microscopically.

The main conclusions drawn from the many experiments were the following: In the case of carbon steels the corrosion decreased with the increase of carbon, having a minimum at 0.35 per cent C, and then rose again. The addition of a third metal in small amounts almost always increased the corrosion, though the results were not regular, nor always concordant; tungsten conferred no gain at all; vanadium was useful only in tap water; cobalt corrosion up to 11 per cent; manganese steels were very irregular; chromium had some remarkable effects. No steel was found sufficiently homogeneous to resist corrosion; even the most homogeneous bar iron (0.07 per cent of C) contained amorphous intergranular cement, and there were strains and twined crystals in all the steels. Yet non-homogeneity was not in itself productive of easy corrosion, for a 19.46 per cent chromium steel (0.85 per cent of C) was not attacked at all in salt solution, though composed of an intimate mixture of carbides and solid solution. The true secret of non-corrodibility seemed to lie in some property—possibly low solution pressure—of the solid solution; the solution pressure of iron was not low. Carbides themselves were not attacked; but they acted as acids, providing cathodes, and the pearlite in them promoted attack, though the pearlite might not itself be attacked; the attack seemed to affect rather the ferrite and the solid solution, which formed the matrix for the carbide. Corroded metals containing free carbide were generally found to be corroded with loose carbide particles; but bigger carbide grains would remain embedded in the solid solution, and the boundaries of the grain were similarly fixed.

Papers were also read by Dr. J. N. FRIEND, and by Mr. S. WHYTE and Mr. PENDRED. The latter gentleman mentioned that he had, three years ago, started experiments, in conjunction with Mr. Harbord, on a rather large scale, taking plates of all sorts of iron and steel, 12 in. square, up to $\frac{3}{8}$ in. thick, and exposing them in London air (which proved worse than salt water), tunnel air, Thames water (which did little harm), acids, exhaust steam, etc. The result was that specimens of the same steel might behave very differently, but that on the whole nothing could be said as to the superiority.

Papers were then presented dealing with the non-ferrous metals—these I propose to summarize in my next letter.

University and Industry

Meeting of New York Section of American Chemical Society

The third of the series of meetings of the New York Section of the American Chemical Society for the purpose of discussing co-operation between the universities and industries was held at the Chemists' Club on Friday evening, April 8, 1916. The chairman, Dr. T. B. Wagner presided. At this meeting the side of the industries was presented by Dr. Wm. H. Nichols and four debaters discussed the question. The two former meetings on November 12, and December 10, were devoted to Columbia University and the Massachusetts Institute of Technology (see this journal Vol. XIII, pp. 885 and 941, Dec. 1 and 15, 1915). This last meeting was well attended and the talks were very interesting and many valuable suggestions were made which should do a great deal toward furthering a closer contact between our universities and industries.

Before the regular program of the evening a bill which is before Congress to compel the use of the Centigrade scale in government publications was read by Colonel Wadsworth. If passed this will mean the ultimate elimination of the Fahrenheit scale in government publications. Colonel Wadsworth urged the society to support the bill. Another bill called the Newland bill which is before Congress was explained by Dr. Willis R. Whitney. This bill provides for the establishment of a department to be known as an engineering or mechanic acts experiment station in every state in the Union. Dr. Whitney said the essence of the bill was that it put research on a business basis in certain colleges in each State. A stipulation of \$15,000 per annum for each State is also provided.

The section was fortunate in having the president of the society, Prof. CHARLES H. HERTY, present, who made a few remarks before the regular program. President Herty spoke of the value of local sections in affecting national thought. He dwelt particularly on the dyestuff problem and paid a splendid tribute to the New York Section for its speedy action in the fall of 1914 in taking up the dyestuff problem and recommending duty rates which should be placed on imports of dyestuffs. He said that recently a convention of Southern cotton manufacturers, almost all Democrats and in a fully Democratic section of the country, had enthusiastically endorsed these rates by a unanimous vote and that they had sent notice of this endorsement to Congress. He also said that local sections could meet more quickly than a national body in cases like the one just cited, and that therein lay their inherent value.

The first speaker on the regular program of the evening was Dr. WILLIAM A. NICHOLS, chairman of the board of the General Chemical Co. Dr. Nichols presented a very valuable address in which he discussed all phases of the problem and made an important announcement which will be quoted further on. He explained that the subject of co-ordination of the university with the industry began very early with him, in fact practically as soon as he graduated from college. He has always followed the technical chemical line and has never failed to avail himself of the valuable assistance of the university professors, consequently he was much in sympathy with the general subject of co-operation between university and industry.

A chemical engineer is more hampered in the making than other engineers because he has not enough prece-

dent to go by. So much of the chemical work done is never published and consequently he labors under a severe handicap. Summer work is a great benefit to his education.

But after all is said and done it is the individual professor rather than the university whose co-operation is needed, and while it is highly desirable that a professor have the advantages which a large institution can confer, nevertheless the fact should not be lost sight of that in many cases the best person will be found in a smaller institution. Dr. Nichols referred to Professor Walker's criticism of the industries in not taking the professors into their entire confidence so that the fullest measure of co-operation could be obtained. Dr. Nichols said the criticism was true and that it was foolish of the industries not to do so. He agreed with Dr. Little's remark that the student should leave the university with a definite purpose in view, and that he should have a fairly good command of English. He deplored the shortcomings of the average technical student in these respects.

Purely theoretical chemistry and applied chemistry are but different phases of the same subject. It is impossible to work out pure theory without benefiting some one. Our industries rest upon the foundations laid by pure chemistry. Let each have its place and let the best co-operation between the two exist.

In visiting Berlin and Vienna some years ago in the interests of the Eighth International Congress of Applied Chemistry, Dr. Nichols said he was deeply impressed with the great interest taken by government officials in the chemical industries. In England, previous to the war, the government took no interest in the chemical industries. Dr. M. O. Forster labored many years trying to bring about such a co-operation. The recently established British Dyes, Ltd., is the first attempt at anything in this line.

The Japanese Government in 1915 passed a bill granting subsidies for ten years to those who would take up the manufacture of chemicals or medicines. The subsidy was to take the form of a guarantee to provide sufficient funds to allow dividends of 8 per cent to be paid on all capital invested for a period of ten years.

Our Oriental friends have gone much farther in government co-operation than we have. The universities and industries should co-operate but if they are the only factors that co-operate we won't get far. If the Universities could turn out some international law makers who would become so imbued with right ideas that they placed patriotism above party, great benefits would result. The universities have always wanted to do their share. The industries are beginning to line up more and more to let them help.

In this latter connection Dr. Nichols outlined a plan formulated by his company for effecting co-operation. "Briefly stated," said Dr. Nichols, "my plan is as follows: We are forming what we call an 'Advisory Council' composed of great chemists in their several lines, located in various universities and schools of science. Each member of the council will receive a modest honorarium, and be expected to attend meetings occasionally at which specific problems will be discussed, as well as any other subject of interest to any of the members. In order that the co-operation may be as complete as possible, I hope to attend these meetings myself, and to have the highly valuable assistance of two or three of the best of our staff.

"Naturally, as the meetings will only be occasional, correspondence between the head office and the members of the council, and between the members themselves, will be frequent. New problems will be referred to the council, and by it referred to the member best qualified

to solve it. The report, if favorable, will after discussion, be passed along to the research department of the company, which in turn, if thought advisable, will bring it before the engineering staff.

"Starting with a small number the council will elect its own members, subject only to the approval of the officials of the company.

The next speaker was Dr. MARSTON T. BOGERT, of Columbia University who said that we must not think of a university as a business enterprise. In fact universities are run at a loss. The chemical industries on the other hand are run purely for making money and have no philanthropic motives. In the dissemination of knowledge there is little co-operation between universities and industries. Our text books are far behind actual practice and a great deal of useless repetition of work is carried on through the lack of publicity given to much of our industrial chemical knowledge. A university chemical department should not perform experiments for a company with the sole idea in view of divulging the information to that company only. Thereby the university laboratory becomes merely a works laboratory. If the universities withdraw from pure research there is little likelihood of its being done anywhere else. Pure science and applied science should work side by side. Industrial research fellowships in university laboratories bring good results.

Dr. Bogert referred to the success of the Mellon Institute in Pittsburgh. He said that at the present time they have over forty fellowships, with appropriations of \$130,000 for same and an additional \$50,000 to \$60,000 required for bonuses. The institute has had to refuse to accept any more work, being so crowded. The Kaiser Wilhelm Institute in Germany which is a splendid example of the pure research institution is supported largely by the manufacturers.

Dr. Bogert made the suggestion that New York City should have an institute of chemical research which could render a great service both to the manufacturer and to the university laboratory.

The next speaker was Mr. E. H. HOOKER, president of the Hooker Electrochemical Co. Mr. Hooker spoke in appreciation of Dr. Nichols' plan for co-operation and said he thought it was the broadest thing yet suggested. He offered the criticism that his company usually had to train chemists to be engineers or to train engineers to be chemists. It is hard for one to get the viewpoint of the other. Mr. Hooker laid great stress on the human factor, as contrasted with the orderly process. He said they found great trouble in getting the chemist to adopt the human factor. He said young graduates should enter their profession with humility, and pointed out several requisites which he considered essential. The first essential is a trained mind. What the industries need is technical graduates of broader culture. A good general education preceding the technical studies is invaluable. English, economics, public speaking—these are too often overlooked. There is nothing equal to Latin and Greek for widening the vocabulary. Single-mindedness and tenacity of purpose are further desirable qualifications.

Mr. Hooker said that the obligations of the industries to the universities is very great and it should be a pleasure to help them. The "tricks of the trade," however, are vital and are of inestimable value. They are the results of long years of experience and are not likely to be disclosed. He spoke of the value of such institutions as the Research Corporation.

The next speaker was Dr. P. A. LEVENE of the Rockefeller Institute. Dr. Levene said that in all true history, science was always following the economic needs of a country. The first science was astronomy. This with

mathematics developed at a time when society was dependent principally on trade. Biology developed with the further advance of agriculture. If science has always followed the needs of industry is there any necessity of compulsion to form agreements by which science may be made to serve the industries? There are two functions of chemical science in the development of the industries. First, the development of new theories which lead to new industries. Second, the chemistry of immediate demands. The universities and industries should be completely divorced and immediate industrial problems should not be worked out in the university laboratory. There, only pure chemistry should reign supreme.

The next paper was presented by Dr. BENJAMIN L. MURRAY of Merck & Co. Dr. Murray was strongly in favor of the idea of extension teaching. Almost every university feels the need of more funds. The promotion of funds and a more intimate contact are the two vital questions. Among the ways of developing contact there are the fellowship idea, intermittent training of the student, including a year or summer spent in the works. The teachers should also go into the industries occasionally. Special lectures at the schools by men from the industries are valuable. Why not have the teachers address the industries also?

A few remarks were then made by Dr. H. P. TALBOT, of Massachusetts Institute of Technology, who enlarged upon the idea of extension teaching and said if one could see the earnestness with which night school pupils go into the work it would be an inspiration.

Dr. JOKICHI TAKAMINE then gave a very interesting little talk on the establishment of chemical manufactures in Japan, alluded to by Dr. Nichols. Dr. Takamine, in commenting upon the enthusiasm of the Japanese people said that when the granting of subsidies was announced, a certain company was started with a capital of 8,000,000 yen (1 yen = about 50 cents). The stock was to be offered for public subscription, and in ordering stock it was necessary to deposit $2\frac{1}{2}$ per cent of the face value in a bank. He said that this $2\frac{1}{2}$ per cent alone which came in, amounted to 17,000,000 yen. Upon a recent trip to Japan, Dr. Takamine said he had advocated the establishment in Japan of a chemical and physical institute with an appropriation of 10,000,000 yen. A committee of fifteen leaders of industry, and fifteen chemists and scientific men was appointed. They have been working hard trying to establish the institute. About two weeks ago a bill was passed in the Japanese Parliament granting 2,000,000 yen for its support, and the Emperor has given 1,000,000 yen from his private fortune, so that the institute is really under way and the balance will be raised from manufacturers.

A few closing remarks were made by the chairman, in which he stated that some final conclusions would be drawn up from all that had been said on co-operation and would be presented at a later meeting. The meeting was then adjourned.

Society of Chemical Industry Meeting

The next meeting of the New York Section of the Society of Chemical Industry will be held in Rumford Hall, Chemists' Club, Friday evening, April 21. The following interesting program has been provided.

"The Application of Centrifugal Force to Emulsions and Suspensions," by EUGENE E. AYRES, JR., of the Sharples Specialty Company.

"The Present Status of the American By-Product Coke Oven Industry," by T. C. CLARKE, consulting engineer.

"The Volumetric Determination of Tin—A Review," by R. L. HALLETT, National Lead Company.

The Western Metallurgical Field

Flotation at Cripple Creek

Indications point to the treatment of a rapidly increasing tonnage of Cripple Creek ores by flotation. The Portland company is already handling several hundred tons per day at the Independence mill, which, when completely remodeled for the new process, will have a capacity of 1000 tons daily. In addition to this, the company has officially announced that its other Victor mill, which was erected several years ago for the cyanidation of low-grade ores, is to be remodeled for flotation with a capacity of 1000 tons daily. When these changes are in effect, this one company alone will be treating 2000 tons per day by flotation, using the Callow air-cell.

The Vindicator will be the second large company to enter the flotation field on a large scale. The first unit, designated as a testing unit, will be erected immediately, and will be based on the results and experience obtained from months of testing on a scale of ten tons per day. The ultimate capacity of the Vindicator flotation plant will be in the neighborhood of 1000 tons per day, but the first unit will treat but 300 tons per day. Run-of-mine ore is to be washed before crushing for flotation. This washing process will produce a high-grade shipping product and will be beneficial to the subsequent flotation by removing oxidized portions of the ore that do not give a good recovery by flotation. The agitation-froth process probably will be installed and thus afford an interesting comparison with the air-bubble process at the Portland mills.

Flotation concentrates from these mills probably will be treated at the valley plants at Colorado City, where high-grade Cripple Creek ores are now cyanided after roasting, or they may be shipped to valley smelters. The gradual abandonment of cyaniding in favor of flotation is an index of the manner in which the latter process may affect metallurgical conditions by offering economic advantages. The practice of cyanidation in the Cripple Creek district was a metallurgical achievement that deserved all the prominence it received. Profits were taken from ore that previously had been waste, and the companies performed a true service of conservation. That successful processes may now be abandoned, reflects only the short life of methods in these days of rapid progress.

Lead Companies Advance Wages.

It has long been customary in certain Western States to base wages for employees in the copper-mining industry on the market price of the metal, increases or decreases being automatic. In the lead industry, however, conditions have not been so favorable until recently, when the market price took a decided rise. Recognizing the justice of an increased wage, lead producers in the Coeur d'Alene district of Idaho have announced a schedule of bonuses to apply automatically when lead is above 5 cents per pound. When lead is at $5\frac{1}{4}$ cents, wages are to be increased 25 cents per shift; at $5\frac{1}{2}$ cents, the increase is 50 cents per shift, and above 6 cents the bonus is 75 cents. In February the price was such that the 50-cent bonus was paid, while for March and April a 75-cent bonus will apply. About 6000 men are affected by this change, and the estimated increase will amount to about \$100,000 per month under present conditions.

Coal Refining in Colorado.

Many of the Western States contain tremendous quantities of lignite coal, aggregating several hun-

dred billion tons, according to the disclosures made by the Bureau of Mines, the United States Geological Survey and the State surveys. The use of these lignites as fuel in the raw state is a wasteful process, owing to their peculiar physical condition and chemical composition. In order to conserve the true value of these coals, some kind of preliminary treatment is necessary. They contain valuable volatile products, which distill at low temperatures and do not even yield their full fuel value when burned in the ordinary furnace. On the other hand, they may be distilled in closed retorts, their distillates condensed and separated, and the carbonized residue briquetted with a binder and used as fuel. Under such treatment the condensed volatile products may become of chief importance, with briquets as a by-product.

Colorado lignite is being refined in this way by the American Coal Refining Co. which has a plant at Denver. The coal is crushed to 1 in. and minus, and distilled at a low temperature in ovens of special construction, 36 ft. long, 9 ft. high and 18 in. wide. These retorts are heated by a part of the gas derived from distillation, the combustion taking place in flues in the oven walls. The time of distillation is two hours, and the weight of the charge in each retort ten tons. Temperature is raised gradually to 500 deg. C., resulting in the distillation of gas, ammonia and tar. The last is an important material, from which other products are obtained by subsequent fractional distillation.

By reason of the low temperature at which the coal is carbonized, the distilled products are different from those obtained from high-temperature treatment. The tar especially varies from that obtained at high temperatures, containing more light oil and creosote and less pitch. When this tar is distilled, it yields at 150 deg. C. from 10 per cent to 14 per cent of light oil; between 150 deg. and 325 deg. C. about 68 per cent of creosote, with a final residue of pitch containing but little free carbon. The creosote product is advocated as a suitable oil for flotation work.

The carbonized residue from the first distillation of the coal is mixed with a binder and briquetted. Following are analyses and fuel values of the raw coal and briquets.

	Lignite	Briquets
Moisture	12.0%	1.35%
Volatile matter	29.0	7.60
Fixed carbon	55.0	84.05
Ash	4.0	7.00
Fuel value	9,900 B.t.u.	14,400 B.t.u.

Flotation at Cobalt

Developments at Cobalt, Canada, indicate that flotation will prove an important factor in the concentration of local ores. At the mill of the Dominion Reduction Co. a 5-ton experimental unit is in operation, handling the product of one of the stamps. The Nipissing company has had a 20-ton experimental unit in operation for some time, treating cyanide tailings from the low-grade mill. The largest installation is that of the Buffalo, which is using the Callow process. The ultimate capacity will be 600 tons per day, and when the plant is in operation it will displace slime concentrating tables. The equipment consists of eight roughing and eight cleaner cells, together with the necessary accessory apparatus. At the McKinley-Darragh mill preparation is being made for the use of two rougher and two cleaner cells, which will provide a capacity of 150 tons per day.

Progress at Anaconda

From the current issue of *The Anode* we note that considerable progress has been made in construction

work. The reconstruction of the concentrator has been completed, and the remodeled portions are now in commission. The oil flotation department is in full operation; the No. 2 roaster is practically complete, and one-third of the furnaces are in service. The large reverberatory furnace, which has been under construction at the converter plant for the purpose of retreating converter slag, is also complete and in service. The construction of the last two of the Great Falls type of converter is now well under way. The addition to the zinc plant is also nearing completion and will probably be in operation during the present month. At Great Falls the grading for the electrolytic zinc plant has been completed, and concrete foundations are being poured.

Company Reports

The annual report of the **Hometake Mining Co.** for the year 1915 shows that 1,573,822 tons of ore was milled, realizing an average of \$4.08 per ton. Bullion receipts amounted to \$6,428,787, which with other income and balance brought forward gave a total receipt of \$7,423,379. Dividends amounted to \$2,210,208. The balance carried to profit and loss account at the close of year was \$1,032,933. Notable among the disbursements other than operating expenses are items of \$13,671 for the aid fund, \$2,800 for benefices, \$50,249 for hospital and \$12,078 for operation of the recreation hall.

The prosperity of the zinc industry is reflected in the annual report of the **American Zinc, Lead and Smelting Co.** for 1915. The company has an outstanding capital stock of \$4,828,000. The total profits from operations, after deducting cost of mining, manufacture, marketing, administration, taxes and interest, amounted to \$5,135,056. Appropriation to depreciation and reserve fund was \$2,642,378. The balance carried to surplus was \$2,651,500. At the beginning of the year the company had notes payable amounting to \$1,130,000 and a bonded debt of \$549,000. The notes have been paid and the bonds converted into stock, par for par. A net deficit in quick assets of \$643,452 was converted into a net surplus of quick assets of \$3,668,706. The following additions to property were made during the year: Purchase of the Roseberry mine at Mascot, Tenn., and erection of a 700-ton mill; increase of capacity of No. 1 mill at Mascot from 1200 tons per day to 2200 tons; options on property in vicinity of Mascot; construction of one block of furnaces, one new kiln and addition to acid department at Hillsboro; one kiln and block of furnaces at Dearing; two kilns and four blocks of furnaces at Caney. The Wisconsin Zinc Co. added valuable leases and built a modern roasting and magnetic separating plant.

The eleventh annual report of the **Nipissing Mines Co.** for 1915 shows a production of 4,097,391 fine ounces silver, at a cost of 19.06 cents per ounce. The gross value was \$2,222,256, and the net receipts \$1,441,427. Shareholders received \$1,200,000. Ore reserves contain about 9,000,000 ounces silver. At the high-grade mill the only change made during the year was an improvement in retorting amalgam, which is now retorted and melted to bullion in one heat in large graphite crucibles in tilting furnaces. The average grade of Nipissing ore treated at the high-grade mill was 2474 oz. silver per ton. Custom ore averaged 2917 oz. per ton. The market for cobalt residue was poor on account of the war, and only 326 tons were shipped. The low-grade mill treated 77,071 dry tons of ore assaying 29.62 oz. silver per ton. The extraction was 87.52 per cent. Stamp duty was 6.57 tons per day. Notwithstanding an increase of 20 cents

per ton in cost of supplies, the total cost of treatment was reduced 7 cents per ton. The Callow screens, which had been used in the tube-mill circuits, collected metallics containing 176,158 oz. of silver, but as extraction was not improved or cost reduced by this procedure, it was discontinued. Experiments are under way to provide a method of precipitation to supersede aluminium dust, as that product has become too expensive to warrant continuing the present method. It is probable that the solutions will be precipitated with sodium sulphide, the resulting silver sulphide being desulphurized by aluminium ingots in caustic soda solution. Tests with flotation have indicated the possibility of making a small additional saving from tailings, and a four-cell unit is in operation. The cost of milling, including transportation and sorting, based on milling 77,183 tons, was \$3.91 per ton. Supplies cost as follows, per ton of ore treated: sodium cyanide, 95.6 cents; lime, 1.98 cents; caustic soda, 7.85 cents; aluminium dust, 27.84 cents; pebbles, 4.66 cents; power, 74.76 cents.

The Iron and Steel Market

The steel market has grown still stronger, accomplishing something that appeared almost impossible. The extremely sharp advances made by the large mills during February and March, amounting to an average of \$10 a net ton on finished steel products generally, except standard rails, might have been construed as representing a desire on their part to bring about conditions whereby they would be able to participate in the higher prices being secured by the smaller mills on a number of products for early shipment. In bars and plates in particular the small mills were securing very high prices for prompt shipment, and as everything is unprecedented in this steel market there was an opportunity to infer that the large mills were ready to renounce forward sales and work themselves into the position of being able to make early deliveries at the fancy prices going for such delivery. There would, then, be a decrease in the volume of business placed so that the mills would begin catching up.

Results have not been in keeping with any such expectation. The Steel Corporation's statement of unfilled obligations at the close of March, made public March 10, is 9,331,001 tons, representing an increase of 762,035 tons. There was heavy buying of rails in March, for 1917 delivery, and assuming that rail obligations increased 400,000 tons there was left, for other products, an increase of 350,000 tons, which with shipments of at least 1,250,000 tons in the month indicates bookings apart from rails of no less than 1,600,000 tons. Yet at the beginning of March steel prices for forward delivery were \$7 a ton higher than on January 1 and by the same amount higher than the level attained in 1907, the highest in fourteen years. Thus at exceptionally high prices the bookings exceed the shipments and the time when they are to fall short of shipments is still in the future. The corporation's capacity is now fully 1,250,000 tons a month, so that the business on books at the end of March, if suitably distributed, would carry the corporation to the middle of November. How long the mills will continue to operate at capacity is a very indefinite problem, seeing that bookings still exceed shipments. When they begin to fall behind there will still be business drifting in that will operate to prolong the period of great activity. It is the usual experience that the mills operate at capacity for a longer time after the edge comes off the market than is generally expected. Such was distinctly the case in 1913.

Despite repeated predictions that orders for war steel

would diminish, the inquiry is still insistent and the volume that actually reaches the market seems to be controlled by the possibilities of the business being placed more than by any predetermination of requirements on the part of buyers.

The embargo on the New Haven system is practically lifted, and the Pennsylvania is being relieved by the transfer of cars which for months have been congesting its tracks in the East. A freer movement of steel to the East, including New England, is beginning, promising a more pronounced scarcity of steel in the Central West. Early last December, when shipments from the Pittsburgh and more Western districts to the East began to be held up, there were fears that steel production would thereby be curtailed or other consumers would be offered too much steel. Nothing of the sort occurred and now the influence in the opposite direction is likely to be quite noticeable.

While the steel makers are naturally interested in so interesting a steel market, their greatest concern at the present time is with respect to the labor situation. Week by week labor has been growing scarcer, and the paying of premium wages has become common in the steel making industry. The influences of the general opening of outdoor work on roads and general construction work and of the great call for farm help, are still to be felt, and are greatly feared. From the time the war started to March 1 the increase in population of the United States due to persons entering the country, less those leaving, is 1,050,000 less than would have been the case if the movement had continued of the average volume shown in the two years preceding July 1, 1914. At such a time, with the iron and steel industry and its coke branch so in need of this particular class of labor, and with conditions growing worse steadily, Congress turns its attention to the passage of an immigration bill with a literacy test advertised to be framed for the purpose of restricting immigration.

Pig Iron

In a generally interesting iron and steel situation the pig iron position is of particular interest. While pig iron has advanced an average of \$6 a ton on this movement, which began in pig iron the middle of last year, or six months later than the advance started in finished steel products, the advance in both unfinished and finished steel is fully \$25 a ton. That is one element in the situation. Another is that the blast furnaces have proved their ability to make much more pig iron than was assumed. A rate of 40,000,000 tons a year has been reached, when a year ago it was doubted whether the industry could materially exceed 35,000,000 tons, and it was thought that if the demand for steel should outrun capacity the blast furnaces rather than the steel works would constitute the throttling point. A third is that consumers generally have in the past few months been so alive to the possibilities of a pig iron runaway that they have covered quite fully, in most instances, to the end of the year, and thus there is at the moment a distinctly quiet market. Finally, there are distinct prospects of the large steel interests requiring much more pig iron than they can make themselves, and of their entering the merchant furnace market. There is a possibility, too, that furnaces will fall behind in deliveries. It is understood that the United States Steel Corporation and the Republic Iron & Steel Company have sold much less than their normal proportions of Southern iron, with the intention either of shipping Southern basic iron to their Northern steel plants or of holding the iron to match sales of it with purchases of iron in the North. We quote: No. 2 foundry, delivered Philadelphia, \$20.25 to \$20.75; f.o.b.

furnace, Buffalo, \$19 to \$19.50; delivered Cleveland, \$19; f.o.b. furnace, Chicago, \$19; f.o.b. Birmingham, \$15 to \$15.50; f.o.b. valley furnaces, 95c. higher delivered Pittsburgh; Bessemer, \$21 to \$21.50; basic, malleable and foundry, \$18.50 to \$19; forge, \$18 to \$18.50.

Ferromanganese is \$175 on contract, but is practically nominal at that figure, offered deliveries to the end of the year being well taken up, with some business closed for the first half of next year. Most of the large steel interests are carrying three or four months' supply in addition to what will become due them on contract. Prompt lots have been bringing \$400 and higher on the few occasions in which any becomes available.

Steel

For months there has appeared reason to believe that with constantly advancing prices a point would be reached at which mills would have some tonnages of soft steel to offer, but the time does not arrive. There are practically no mill offerings at any price, and even the middlemen have practically nothing. If market prices are to be quoted they can be reached only by a combination of uncertain inferences, at, say, \$45 for Bessemer and \$45 to \$50 for open-hearth, for either billets or sheet bars, but these quotations are practically nominal. They appear to be the figures that are least likely to be regarded as either too high or too low. Steel rejected under war specifications is bringing \$40 and higher, although the buyers as a rule are getting material far from that which they would pick out. If the high carbon is not objectionable the high manganese is undesirable. Sulphur and phosphorus are, of course, much lower than the average buyer requires. Size seems to be the principal determining point. Stock lists of rejected steel with single items sometimes involving thousands of pounds rather than tons or carloads are eagerly scrutinized. Ordinary forging billets are \$65 minimum, while war steel billets are \$75 and higher. Ordinary rods are nominally about \$60, with high carbon rods bringing \$75 to \$85.

Fixation of Atmospheric Nitrogen Before Congress

The House of Representatives, by a vote of 224 to 179, has stricken out section 82 of the military bill, containing an appropriation for the Alabama Power Co.'s Muscle Shoals project. But the fight for this is going on.

On March 31 Senator Oscar W. Underwood in a remarkable speech (*Congressional Record*, Vol. 53, No. 86, page 6016) discussed the atmospheric nitrogen fixation problem from the preparedness viewpoint. On account of limitations of space we can only say that it was an unusually able speech from a technical standpoint. Senator Underwood favors the cyanamid project rather than the Du Pont project (mentioned in our issue of April 1, page 362). He accused several advocates of the latter project of lobbying. They have since replied and denied the charge. Senator Underwood introduced the following amendment:

That to provide for the fixation of atmospheric nitrogen, by improvement of navigation and development of water power, necessary for the manufacture of nitric acid in times of war and fertilizers in times of peace, the Board of Engineers for Rivers and Harbors, subject to the approval of the Secretary of War, is hereby authorized and directed, first, to hold hearings and conduct negotiations for the purpose of determining upon a suitable air nitrogen process and the terms under which it can be made available, and second to select a suitable site on a navigable stream in the United States for the construction of the necessary dam, locks, substructure, power house and hydroelectric equipment. The Board shall report its findings, with estimates of cost, to the Congress at the earliest practicable time, accompanied by recommendations as to what plans should be adopted for providing the government an assured and adequate supply of nitric acid in times of war, and, consistent with this purpose, for effectively and economically serving to the greatest extent practicable the agricultural interests of the country in the manufacture of fertilizers in times of peace.

Mr. Frank S. Washburn, president of the American Cyanamid Company, has issued for private circulation a very ably written pamphlet entitled "THE FACTS IN THE NITROGEN CASE NOW BEFORE CONGRESS," which contains a great deal of very interesting information. In part, some of the information is new, having not been divulged to the public before in print.

From the technical standpoint perhaps the most interesting part of the pamphlet is the appendix which we herewith give in full:

"More or less uniformed opinion has been expressed as to the relative characteristics of the two principal processes for the fixation of atmospheric nitrogen, known as the 'arc process' and the 'cyanamid process,' respectively. The arc process proceeds on the simple fact that at the high sensible temperature of the electric arc nitrogen and oxygen combine chemically to form a nitrous gas which when taken into aqueous solution becomes weak nitric acid. The cyanamid process is based on the simple fact that a carbid, such as calcium carbid, when in a finely subdivided state will, under high temperature, combine chemically with nitrogen gas to form a cyanamid. This can be easily converted to ammonia by the addition of steam and ammonia gas by a contact process can be oxidized to weak nitric acid.

"The arc process requires for the fixation of a unit of nitrogen between five and six times as much power as is required by the cyanamid process. For the production of 180,000 net tons of concentrated nitric acid per annum 540,000 continuous horsepower is required by the arc process and 100,000 continuous horsepower by the cyanamid process, which at \$100 per horsepower installation cost is the difference between \$54,000,000 and \$10,000,000.

"The total installation cost of the arc process is excessive compared with the installation cost of the cyanamid process, particularly where the cost of developing power is not extremely low. With the cost of power installation at the moderate American figure of \$100 per continuous horsepower on the switchboard a plant of 180,000 net tons of concentrated nitric acid per annum by the arc process would cost \$80,000,000 and under the same conditions a plant of the same capacity by the cyanamid process would cost \$30,000,000. For the production of fertilizers alone the disproportionate cost of plants of equal capacity is much greater than indicated by the figures above for the production of nitric acid.

"Concentrated nitric acid by the arc process, taking the installation cost of power of \$60 per continuous horsepower on the switchboard, costs per ton to produce one-third more than by the cyanamid process. This disproportion is, of course, correspondingly greater where the cost of power installation is \$100 per continuous horsepower. The disproportion in the cost of producing equivalent quantities of nitrogen in the form of fertilizer alone is greater than for nitric acid. Even with power at what would be an abnormally low figure in the United States, namely, a \$10 operative cost per continuous horsepower on the switchboard, the pound of nitrogen produced by the arc process costs for power alone as much as the total cost of the pound of nitrogen by the cyanamid process, including power, materials, labor, interest, amortization and depreciation.

"The world production of nitrogen by the way of the arc process is equal to 32,000 net tons and by the way of the cyanamid process to 200,000 tons per annum. It is interesting to note that the world production of nitrogen by the arc process is only two and one-half times the productive capacity of the single plant of the American Cyanamid Company at Niagara Falls, Canada.

"The arc process, except as to some minor unsuccessful attempts, has been confined to Norway whereas the cyanamid process has found application in Norway, Sweden, Germany, Austria, Italy, France, Japan and Canada.

"Persons of late have seen fit to throw doubt upon the commercial practicability of the cyanamid process for the production of nitric acid because of the lack of experience in this country in the oxidation of ammonia, which is one of the steps in the production of nitric acid by cyanamid. There are a number of processes for the oxidation of ammonia. The particular process in the development of which the American Cyanamid Company collaborated has application in Germany equivalent to the production of 120,000 tons of concentrated nitric acid per annum. The art is so well established in Germany that the details are now subjects of discussion in the technical periodicals,* and

*In this connection the article on page 425 of this issue, based on a recent article in *Metall und Erz*, will be found of particular interest.—Editor MET. & CHEM. ENGR'G.

an issue of the *Chemiker Zeitung*, so late as December, 1915, contains a discussion of the subject, setting forth the results guaranteed by the projectors of two of the processes. In this connection their guaranteed efficiencies vary from 90 per cent to 95 per cent. It should therefore be quite clear, without accepting the mere statement of interested parties, that the process has attained practical perfection in the only respect in which for a time it was deficient, namely, as to chemical efficiency. An English company is establishing cyanamid nitric acid plants throughout the allied countries of Europe and guaranteeing 90 per cent efficiency. The costs of production are substantially 70 per cent of what it costs to manufacture nitric acid by the way of Chilean nitrate. The art was quite new when the European war began and the enormous demand throughout Europe for nitric acid has given it an extraordinary impetus and brought about refinements in efficiency and in the cost of production which otherwise might have taken years to accomplish."

In the pamphlet itself, Mr. Washburn discusses after some introductory remarks first "the military demand" for nitrogen, due to the fact that all military explosives are made from and by the use of nitric acid and that nitric acid can only be secured in practicable quantities from nitrate of soda from Chile or by the fixation of atmospheric nitrogen.

"Germany had available within her borders at the outbreak of the war 660,000 tons of nitrate of soda. She imported from Chile during 1914 up to the outbreak of the war on Aug. 1 in excess of 800,000 tons and it is estimated that she captured at Antwerp another 200,000 tons. All of this supply was consumed during the early months of the war, during which period Germany expanded on an enormous scale the air nitrogen industry, already well established in that country. To this end she expended substantially \$100,000,000, employing an additional 300,000 continuous horsepower. Even the Allies, to whom the road to Chile is completely open, are employing 500,000 continuous horsepower in the fixation of atmospheric nitrogen in the form of explosive materials and are actively engaged in the establishment of nitric acid factories by the way of the cyanamid process throughout their various countries."

Mr. Washburn then takes up the economic demand for nitrogen. Man's chief concern is food. Food prices rose 80 per cent in this country from 1896 to 1912. Limiting the price of food is largely a question of lowering the cost of its production. Cheaper production is only compatible with an increased crop return per acre cultivated without increased expenditure of human labor. If this be true of European countries with 50 cents per day field labor how much more important is it to this country with two dollars a day labor.

In 1907 Germany had 43,000,000 acres sowed to wheat, barley, rye, oats and potatoes, and harvested therefrom 3,000,000,000 bushels, while from 85,000,000 acres sowed to the same crops in the United States, American farmers harvested only 1,875,000,000. From less than one-half the area German farmers harvested double the number of bushels. Why this extraordinary difference? The answer lies chiefly in the fact that Germany uses seven times as much fertilizer as the United States to the average acre cultivated. Is it surprising that during the period in which the cost of food rose in the United States 80 per cent it rose in Germany only one-half as much?

For the needs of the American farmer the American Cyanamid Co., by extensive research work, has developed a universal fertilizer, a cheap ammonium phosphate in which the nitrogen content is a secondary product of the cyanamid process, while the phosphoric acid is extracted from phosphate rock by a new process.

The principal factors that any comprehensive nitrogen plan should possess are formulated by Mr. Washburn as follows:

"For National Defense.—The plant should provide in time of war not less than 180,000 tons of nitric acid per annum; it should to the extent of 25 per cent to 50 per cent of the ultimate capacity be in readiness for operation within eighteen months; it should place upon the country the least

burden and therefore the minimum taxation for its support; it should add to the country's facilities for production and not merely divert existing materials from established uses.

"For Agricultural Advancement.—The plant should provide a sufficient quantity for universal use of cheaply produced, highly concentrated complete fertilizer.

"Various Federal legislative plans have been suggested for meeting the national military and economic problem presented by our nitrogen requirements. With the preceding facts in mind one is prepared to pass judgment upon their general sufficiency to cope with the situation.

"Du Pont Project.—The E. I. du Pont de Nemours and Company are credited with offering a solution for the nitrogen problem. This, we believe, is a misconception of the du Pont purpose, although late communications addressed to the Secretary of War and to certain Senators, as well as newspaper interviews attributed to their representatives, seem to indicate a confusion in the minds of the du Pont officials of their company's exact place in the nitrogen situation. The du Pont Company has announced that \$20,000,000 is available for the establishment within the borders of the United States of a nitric acid plant, providing an acceptable water power site with the requisite permit can be secured. From the late official statements of du Pont representatives this expenditure would be sufficient to complete at the end of four years the development of 120,000 hydroelectric horsepower and the construction of a nitric acid plant with all its appurtenances capable of manufacturing 40,000 tons of nitric acid per annum. They state that it is not their purpose to produce any fertilizer. The Birkeland-Eyde Arc Process for fixing atmospheric nitrogen in the form of nitric acid is to be used, the American rights to which were secured by the du Pont Company about two years ago.

"The du Pont Company are large producers of powder in the manufacture of which they use considerable quantities of nitric acid, approximately in normal times 40,000 tons per annum, made from Chilean nitrates at a cost (as to a part thereof) greater than that at which it can be produced with cheap water power by the arc process. They plan to have in readiness at the end of four years a plant for furnishing for their own use a quantity of nitric acid equivalent to about 20 per cent of the anticipated minimum this Government would require in the event of war. There is no intention of manufacturing fertilizer, nor any possibility of doing so, except in practically infinitesimal quantities and of a kind inappropriate for general use under American conditions. Were the plant proposed by the du Pont Company ready to manufacture to-day at full capacity instead of four years from now, the present nitrogen situation would be altered only to the extent of having a source of nitric acid supply within the country equivalent to approximately 20 per cent of the probable war demand and available only at the sacrifice of mining and quarry operations, as necessary in war times as in peace, by taking from them their necessary blasting powder.

"Cyanamid Project.—The author of this paper was asked by the War Department about six months ago to recommend to the Government means by which it could have an assured ample supply of nitric acid in event of war. The general idea so far as it had been developed by the War Department was to build a Government plant of war time capacity to stand idle for the most part during peace times when the Government's use for nitric acid is inconsiderable. Rather exhaustive studies were made and the resulting estimates along the lines projected by the Department were placed before it, covering two quite different processes, the cyanamid and the arc, the first involving an expenditure for the full plant of approximately \$30,000,000 and the second, not including the requisites for shipping the product, approximately \$70,000,000.

"The questionable operative practicability of such a plan, the great useless standing investment through long years of peace and the very grave doubt as to Congress appropriating so large a sum for so unusual a purpose were sufficient incentives to developing a plan under which there would be no operative risks, only on inconsiderable idle investment and no additional expenditure on the part of the Government except for the development of the requisite water power at such site as the Government might select, and the repayment to the Government by the lessee of 3 per cent per annum on the cost thereof. The plan in detail, as explained to various Congressional committees upon their invitation, is as follows:

"First.—The Government is to develop 100,000 primary hydroelectric horsepower at any place which will serve the military and commercial purposes to which the power is to be applied. This would call for an installation of 125,000 to 130,000 hp. capacity measured on the switchboard, which, taken at an assumed installation cost of \$100 per horse-

power, would amount to \$12,500,000 to \$13,000,000. The Government is to own the entire plant.

"Second.—Private capital is expected to construct at an estimated cost of \$23,000,000, including working capital, a fertilizer plant, rent the requisite hydroelectric power for its operation from the Government and pay 3 per cent on the Government's investment for developing the same, together with the cost of operating the power house. The fertilizer plant is to produce a high grade, concentrated universal fertilizer equivalent in plant food constituents to 2,200,000 tons of standard 2-8-2 fertilizer goods.

"Third.—Private capital is to install at an estimated cost of \$1,000,000 the buildings and special appliances necessary to introduce a subsidiary process, exclusive of the fertilizer processes, by which 20,000 tons of nitric acid per annum would be produced for the Government's peace time requirements.

"Fourth.—The Government is to install at an estimated cost of \$5,000,000 the buildings and special appliances necessary to introduce a subsidiary process, exclusive of the fertilizer processes, by which the plant will stand in absolute readiness to produce 90,000 tons of nitric acid per annum and have all the buildings and everything, except easily procurable articles of merchandise, in store on the premises necessary to complete the plant within three months for an additional 90,000 tons.

"Fifth.—The Government is to have nitric acid at all times in such quantities as it may desire at the cost to the manufacturer for furnishing it plus such additional amount as profit as the Secretary of War in his judgment may determine from time to time as reasonable.

"Sixth.—Provisions are to be made against exorbitant or discriminatory prices being charged for the fertilizer produced under this plan.

"Seventh.—Provisions are to be included by which 45,000 to 90,000 tons nitric acid capacity shall be in readiness within eighteen months at moderate increased expenditure if any at all."

Mr. Washburn then discusses the production of ammonia from by-product coke-ovens. He concludes that the production of coke-oven ammonia from year to year varies greatly and depends on the fluctuations of the iron industry; that the ammonia produced at present from by-product coke-ovens is completely consumed in industries from which it could hardly be withdrawn, without great damage, in case of war (37 per cent of the total coke-oven ammonia is used in cold-storage, 10 per cent in explosives and chemicals and the balance in fertilizers). Moreover nitric acid from coke-oven ammonia would cost considerably more than nitric acid secured by way of the fixation of atmospheric nitrogen.

"Germany, the greatest European country in metallurgical industry, producing 90 per cent of her coke supply in by-products plants, turned to atmospheric nitrogen for her war requirements.

"One of the fundamental principles of the [by-product coke oven] industry is that the natural place for the by-product coke oven is in the hands of the large producers of iron, such as the United States Steel Corporation, as an added economy in the production of their principal product. There are a number of operative demands in connection with the handling of the by-product oven which place limitations upon the extent to which it can be profitably employed. The requisite combination of favorable conditions is rather uncommon and it is a mistake to assume that the by-product coke oven is universally practicable, and that its future growth is to be measured in direct ratio to the future coke consumption of the country. One of the serious limitations upon the growth of the by-product coke oven is the relatively great investment involved therein. Notwithstanding these facts some enthusiasts have suggested that coke ovens could be erected wholesale for the purpose of supplying ammonia for the making of nitric acid in times of war. In order to supply by this means the amount of ammonia required in the manufacture of 180,000 net tons of concentrated nitric acid per annum an investment of \$100,000,000 would be required in coke oven plants alone and it would require coking about 27,000,000 tons of coal per annum, or 75,000 tons per working day. In conclusion upon this subject it may be said that to depend upon ammonia liquor from by-product coke ovens would have the vital defect of not subscribing to the first principle of preparedness, which is to add something to the country's protective capacity in order to meet war conditions rather than to subtract from it."

Mr. Washburn then takes up briefly one proposed method of government ownership and operation and finally discusses the possibilities of development by private capital as follows:

"Nitrogen in time of peace is consumed in the form of fertilizer alone to an extent seven times as great as in the form of nitric acid. The increased war time demand for nitric acid is enormous. No private interest can afford to prepare itself to manufacture nitric acid to meet war demands for the reason that it would have, over years of peace, idle investment upon which there would be no return.

Cheap water power is the chief requisite in the fixation of atmospheric nitrogen. The United States is not a country of cheap water powers. It is quite the contrary. The disproportion as to the annual cost of the continuous hydroelectric horsepower, as shown in the great mass of testimony before various committees in Congress, is from three to six dollars in Norway to twelve to twenty dollars in the United States.

No private interest engaged in the fixation of atmospheric nitrogen seeking the greatest commercial advantage would locate its factories in the United States, nor if so located would it equip itself to produce more than a very moderate amount of nitric acid. The markets of the United States can be best filled from plants located at the cheap Canadian water powers. The only means by which hydroelectric power can be cheaply enough furnished to the fixer of atmospheric nitrogen at any practicable manufacturing sites in the United States is through the Government making the investment for power and renting it to the user by charging the low rate of interest at which the Government can borrow money.

Furthermore, industries of the nature of the fixation of atmospheric nitrogen are new to American investors and where the cost of developing the necessary power constitutes, as it frequently would in the United States, one-half of the total investment, to be relieved of making the investment for power brings the amount which must be raised by private investment within such an amount as will meet the limitations of the American investor.

The nature of the author's interest and his purpose in presenting a nitrogen plan for the consideration of the Government has been misunderstood by certain senators and representatives. The following facts may serve to correct any misunderstanding:

1. The American Cyanamid Company is representative of one of the four industries which must have an extraordinary amount of extremely cheap water power, the others being the carbide industry, the aluminum industry and the arc process. The Union Carbide Company is the sole representative in the United States of the carbide industry and it has secured water powers in Norway for future developments. The Aluminum Company of America, the sole representative of the aluminum industry in the United States, is confined to the use of those powers which are within range of the necessary raw materials, and this company has had the advantage of being early in the field in its demand for power and has secured the cream of the large cheap powers in the United States. The arc process has not so far found its way outside of Norway except in an experimental way. The du Pont Company states that it was their purpose to establish the arc process in Canada. The Cyanamid Company is in Canada and has laid its plans for remaining there. These facts alone should be sufficient to establish in the public mind what is definite knowledge to those engaged in large electric furnace operations, namely, that such industries must for their commercial success seek sites for manufacturing in those countries where ample, cheap hydroelectric power can be developed.

2. The American Cyanamid Company is engaged in extensive developments for the purpose of providing for the use of the farmers of this country a great supply of a concentrated chemical compound of nitrogen and phosphoric acid, constituting a fertilizer of superior merit in all respects.

3. The American Cyanamid Company has made no proposal or advances of any sort to the United States Government. It has not asked for nor does it desire Government aid or assistance.

4. The fact of the author's interest in water-power development and past association with particular water-power sites has no relationship of any kind whatsoever to the nitrogen problem or the plan he has suggested for solving it.

5. The author has done his best in compliance with an unsought invitation from the War Department to suggest a plan which he believes would be of extraordinary national benefit and practicable of accomplishment.



The New Chemical Laboratory of the University of Illinois

History of the Chemical Department at Urbana-Champaign—Description of New Chemical Laboratory

The dedication of the new Chemical Laboratory of the University of Illinois at Urbana-Champaign will take place on Wednesday, April 19, 1916. It will be a great event in the history of the University of Illinois: Governor Edward J. Dunne of Illinois, will preside, and addresses will be made by President Edmund J. James, Dr. W. R. Whitney, and Dr. Alexander Smith. The importance of the event for the future of chemistry in America will be appropriately indicated by the fact that the American Chemical Society will hold its fifty-second general meeting in connection with the dedication exercises.

A historical review of chemistry at Urbana-Champaign in the past is particularly fitting at the present time. It has been written with a full personal knowledge of the facts and with the loving heart of the historian in unison with his subject, by Prof. S. W. PARR who has been connected with the University of Illinois since 1890. It is published in the "University of Illinois Bulletin 25." From Professor Parr's article the following sketch is extracted. While it is restricted to the most important facts, we hope it will be found interesting enough to encourage our readers to look up and read Professor Parr's article in full in the "Bulletin."

* * *

The opening of the University of Illinois occurred on March 11, 1868, and in the first annual report of the Regent (President) it was said to be "especially important that an appropriation should be made to fit up, at once, a chemical laboratory."

In the autumn of 1868, A. P. STUART, of Lawrence Scientific School, Harvard University, was elected as

the first professor of chemistry at a salary of \$2,000 a year. The initial cost for equipping the laboratory was \$978. The following plan of compensation for chemicals used by the students was evolved by Professor Stuart:

"For a course of two hours daily, excepting Saturday, during a term of twelve weeks the sum of \$12 shall be deposited by each student. For a course occupying four hours daily the sum deposited shall be \$24, and for a course of six hours the sum deposited shall be \$36. An account shall be kept by the Professor of Chemistry with each student; all articles shall be charged to him at cost and a credit entered for all articles returned in good condition, except that a charge of 20 per cent of the cost shall be made for the use of same. Such percentage, however, shall not exceed \$3 for the term. Students pay the cost value of the apparatus broken or destroyed by them individually. . . . All money received from students for chemicals and apparatus shall constitute a distinct fund from which the Professor of Chemistry may draw to purchase supplies from time to time as occasion may require."

In 1869 the Legislature appropriated \$5,000 and with the revenue thus provided the first laboratory was equipped and operated. It was located in the basement of the south wing of the original University Building. The equipment of the laboratory was materially increased as a result of a trip to Europe by Professor Stuart during the summer of 1871 for the purpose of selecting in person the apparatus desired. Among the list of accessories was a platinum retort for making hydrofluoric acid, weighing 1000 grams and costing \$200. (It was exchanged in 1903 for about \$800 worth of much needed platinum dishes.) Professor Stuart paid careful attention to the proper selection of chemical journals and reference books for the library. Under what difficulties he had to run the laboratory is evident from the

facts that the only water available was from the college pump, that there was no city gas supply, and, of course, electricity by the meter route was unknown. A kitchen stove was installed in the laboratory and this was the only source of heat. When no appropriation for a new laboratory was forthcoming, Professor Stuart resigned at the end of the year 1873-4.

"Whether it may be taken as an index of the low cost of living or the economical propensities of the professor is not stated, but it used to be remarked about the campus that he came at a salary of \$2,000 per year, stayed five years and took away \$10,000 with which to start a banking business in the West. However, he was unmarried, and lived in the building in a sort of supervisory capacity."

HENRY A. WEBER was Stuart's successor and M. A. SCOVELL was elected in 1876 assistant professor of chemistry, in charge of agricultural chemistry. An appropriation for the new chemical laboratory was secured early in 1877 and amounted to \$40,000. City gas became available and water under pressure was provided from a large steel tank supported in the mansard story and kept supplied by a pump in the basement. An unfortunate disagreement with the Board in 1882 resulted in the withdrawal of Professors Weber and Scovell.

Professor WILLIAM MCMURTRIE was appointed head of the department in September, 1882. The position of professor of agricultural chemistry was not revived. Dr. A. W. PALMER served as First Assistant in Chemistry. When Professor McMurtrie resigned in 1888 to become chief chemist for the Royal Baking Powder Company, Dr. Palmer also resigned. Dr. J. C. JACKSON became professor of chemistry, but his reign was short-lived. Dr. A. W. PALMER was recalled from Europe in 1889 and shortly afterwards was made a full professor.

"It should be noted that at this time a new life and altogether different aspect of affairs were in evidence at the University. The most potent factors were doubtless the change in name from the 'Industrial' University to the 'University of Illinois' in 1885, and the increased revenue from the action of the federal government in the Hatch Act of 1887 and later in the Morrill Land-College Aid Act of 1890. These two measures were to augment the revenues at the outset by over \$30,000 annually. This was a relatively large sum since the total state appropriation for the year 1889-90 was only \$31,750 of which \$16,000 was designated as for 'expenses and instruction.' The total state appropriation for the biennium 1889-91 was \$59,000."

In December 1890 SAMUEL WILSON PRATT was appointed to the chair of analytical chemistry, but in 1894 it was decided that his title be changed to that of professor of applied chemistry and that Dr. Palmer's and Dr. Pratt's departments "be separately organized as agreed upon between themselves."

The Chemical Club was organized in 1892.

The Illinois State Water Survey was organized in 1895 under Dr. Palmer's direction with C. V. MILLAR as "assistant in chemistry in the State Water Survey."

In the spring term of 1899 the honorary chemical fraternity, Phi Lambda Upsilon, now grown to national status, was organized.

In the early morning of Aug. 5, 1896, the laboratory was struck by lightning, and very considerable damage was done.

In 1901 an appropriation of \$100,000 was secured for the Chemistry Building. This amount was less than half of what the department considered essential. The question to be decided, therefore, was whether to build one-half of the laboratory and equip the same for work, or to plan a building which would take care of the increase in students for the coming twenty-five years, but

with very little in the way of equipment. If the first plan were followed it was absolutely certain that a second large appropriation would have to be asked for within ten years, and the outlook for such a procedure was altogether discouraging. The other plan, therefore, was followed with the result that when the contract was let for the building there was only \$800 left for equipment. This was sufficient to place four new desks in the quantitative laboratory and supply a few hoods. Every desk in the old building was moved over. Many of these were marred from the effects of the fire and all were battle-scarred from twenty years of strenuous use. It certainly was a distressing feature in making the new building ready for occupancy in the fall of 1902 to see these old wrecks hoisted by rope and tackle to the third story and skidded into place for service again with the Freshmen. Fortunately at the next session of the Legislature, in 1903, an item of \$20,000 was allowed under the designation of "material and equipment for the chemical laboratory." This item was repeated in the budget for a number of succeeding sessions and very materially relieved the situation. At least the departments were able to keep fairly abreast of the rapid increase in the number of students.

On Feb. 2, 1904, occurred the death of Professor Palmer. He had been ill but a short time. The direction of the State Water Survey had brought on a tremendous amount of work and responsibility, especially in connection with the survey of the Illinois River before and after the opening of the Chicago Sanitary Canal. His second report covering the work from 1897 to 1902 and embodying the results of the Illinois River and Sanitary District Survey is a monument to his untiring industry and ability. He literally gave his life in the service of the University and the State.

Dr. H. S. GRINDLEY, who had been appointed Assistant Professor of Chemistry in 1895, and Associate Professor in 1900, continued in charge of that department for the remainder of the year.

At the meeting of the Board for August, 1904, the following recommendation by the President was passed:

"(1) That the Department of Applied Chemistry be discontinued as such and that there be one Department of Chemistry. (2) That Professor Parr's title be continued as that of Professor of Applied Chemistry and Associate Professor Grindley be made Professor of General Chemistry. (3) That the headship of the department be divided so that Professor Parr shall have general charge of all matters pertaining to instructors and instruction, and Professor Grindley as Director of Laboratory shall have charge of and be responsible for all business and material affairs. They will then so adjust matters that each shall have supervision over definite subordinates and courses of instruction, and each be directly responsible for the men and work so assigned."

From September, 1904, therefore, the consolidation of the two departments was effected and the work carried on as above ordered until the appointment of Dr. W. A. NOYES as "Professor of Chemistry and Director of the Laboratory" beginning Sept. 1, 1907. At the same time Dr. Grindley was appointed chief in Animal Chemistry in the Agricultural Experiment Station and Professor of Animal Chemistry in the College of Agriculture. The State Water Survey was put under the supervision of Professor Parr in February, 1904, and so continued until the appointment of Professor EDWARD BARTOW, Sept. 1, 1905.

The Illinois section of the American Chemical Society was organized April 24, 1906, with twenty-six members. At the present time there are 152 members of the section and all but thirty-seven are connected with the University.

In April, 1908, the Zeta Chapter of the National Chemical Fraternity, Alpha Chi Sigma, was installed.



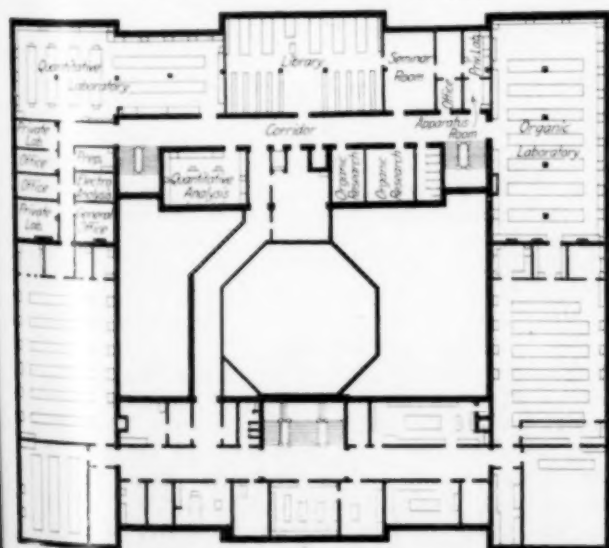
GROUND FLOOR—STATE WATER SURVEY, INDUSTRIAL CHEMISTRY, VENTILATION SYSTEM

The new building entered in 1902 soon became crowded to such an extent that distress signals were in evidence even when only one-half of the estimated time of twenty-five years had passed in which it was assumed there would be ample room. Instead, the need for an addition to the building was urged upon the legislative session for 1913. The addition to the University fund from the mill tax, available after July 1, 1913, made it possible to proceed with the plans for the new addition and the contract was let Aug. 14, 1914.

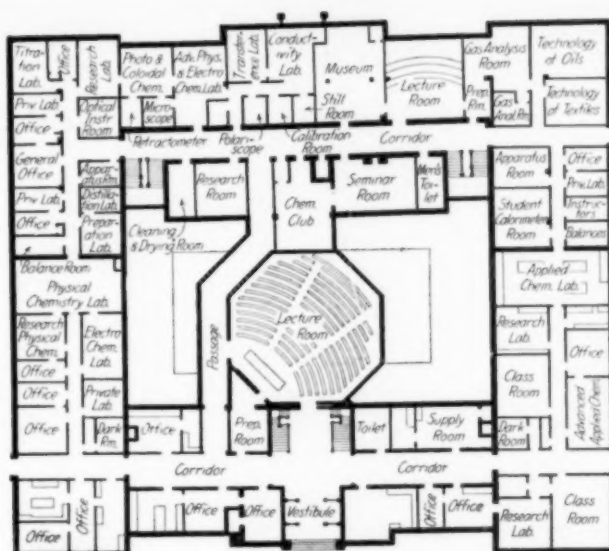
It is of interest to note that the number of students specializing in chemistry has grown from 14 in 1872 to 245 in 1915, of whom 75 are in the graduate division.

Description of the Laboratory

The building erected in 1901-2 as a home for the Department of Chemistry resembled the letter "E" in shape, the extreme dimensions being 230 ft. along the front and 116 ft. along the wings. This building contained 77,884 sq. ft. of usable space, which it was estimated would provide ample room for the needs of the department for at least twenty-five years. The growth has been so rapid that in 1914 work was begun upon an addition which has a larger capacity than the original building. The cost of the addition is more than double that of the original building. The completed building



SECOND FLOOR—QUANTITATIVE ORGANIC CHEMISTRY



FIRST FLOOR—PHYSICAL AND INDUSTRIAL CHEMISTRY

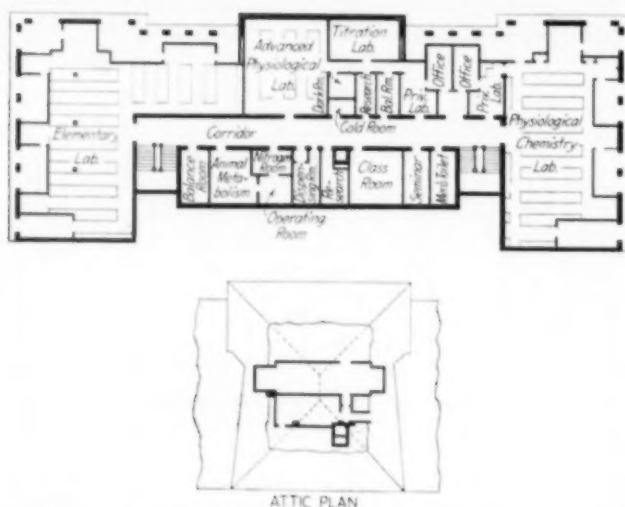
is in the form of a hollow square, 231 ft. by 202 ft., containing 164,282 sq. ft. of working space. The center is occupied by the main lecture room, which is lighted by a skylight; two large ventilator fans are housed in the court, which arrangement prevents annoyance from noise and vibration.

The old portion of the building is not fireproof, but is divided into three sections by fire walls, while the new part is built of fireproof material. The floors are a combination of reinforced concrete joists and hollow tile, the concrete covering the tile to a depth of 2 in. Upon the concrete the electrical conduits are laid and these are covered with a top layer of concrete, rubbed to a smooth surface. The top surface consists of a layer of "rezilite mastic," about $\frac{1}{8}$ in. in thickness. This is a preparation of elaterite, containing some asbestos fiber, which gives elasticity to the floor, and is superior to asphalt because it does not yield under the pressure of heavy furniture. The floors in the halls have the terrazzo finish.

The roof is constructed of concrete slabs which are covered with wood sheeting, building paper and slate. The purpose of the wood sheeting is to give an air space for insulation purposes and to furnish a better means of laying the slate. Being entirely covered on



THIRD FLOOR—GENERAL CHEMISTRY, QUALITATIVE ANALYSIS, BACTERIOLOGY (TEMPORARY QUARTERS)



FOURTH FLOOR—GENERAL AND PHYSIOLOGICAL CHEMISTRY, ATTIC, HYDROGEN SULPHIDE, DISTILLED WATER

all sides by fireproof material, the sheeting does not increase the fire risk.

The minor partitions are made of "pyrobar" tile. A brick wall separates the old and the new portions of the building, making it possible to completely shut off either side. There is almost no wood used in the new part, the largest amount being for doors and window frames. A majority of the rooms are finished with a wooden base board, chair rail, hang rail and picture molding.

Abundant hood space is provided in all parts of the building. The hood construction used throughout the building consists of the following: The top is a single frame of plate glass with wire reinforcement, so set as to avoid as far as possible the gathering of dust; the linings are white tile; the doors are counterpoised, the weights being attached by means of a creosoted hemp rope. The pulleys and axles are made of wood. Each hood is connected with a flue which runs to the top of the building independently of other hoods. Ventilation is by forced draft.

In the larger laboratories the air is brought in at the corners of the room, and distributed at various openings along the ceiling, while the foul air is formed out through the hood flues. In this way there is an even distribution of the fresh air in all parts of the room, and the air is changed six times per hour.



LABORATORY OF ORGANIC CHEMISTRY,
UNIVERSITY OF ILLINOIS

In the laboratories for elementary chemistry there are upon the student desks special ventilation conduits which are connected with exhaust fans capable of changing the air in these laboratories eleven times per hour. These conduits rise a few inches above the level of the table top, so that the gases are drawn downward and discharged into a large flue. The toilet rooms are provided with special exhaust fans giving a very thorough ventilation.

The window sills in the halls and offices are of white marble, and those in the laboratories are of alberene stone, which material is also used generally for shelves and table tops. All tables are supplied with gas, water, waste and suction; some also have blast, high-pressure steam, distilled water and hydrogen sulphide. The building is completely wired with five electric systems: 10, 110 and 220-volt direct current and 110 and 220-volt alternating current. Many laboratories are also connected with the storage battery system. In the attic a large water distillation apparatus is placed as well as a hydrogen sulphide generator. The hydrogen sulphide is stored in a 500-gal. gas tank, which permits the distribution of the gas to various parts of the building under constant pressure.

Besides the main lecture room, which seats 390, the equipment includes one smaller lecture room, seven recitation rooms, four seminar rooms, a library, a museum and a room for the Chemical Club. Fireproof vaults and an elevator are available from all floors.

The general plan of space distribution is to have most of the offices, the library and the research laboratories in the new part with the routine laboratories in the old; the office of the director and the general executive offices of the department are in the old portion of the building near the main entrance of the west front. The large stock room and the ventilation equipment are also in the old part. There are five entire floors available for laboratory purposes in the new addition. Individual desks are provided for 1280 students in general chemistry and qualitative analysis, 400 in quantitative analysis, and 192 in organic chemistry.

Centrally located, on the second floor of the new addition, there is an exceptionally well-equipped departmental library.

In an adjoining seminar room is the Palmer Memorial Library, containing the private collection of chemical works and journals of the late Dr. Arthur W. Palmer.

The Department of Chemistry contains the following divisions: Divisions of Inorganic and Analytical Chemistry, Division of Physical Chemistry, Division of Organic Chemistry, Division of Physiological Chemistry, Division of Sanitary Chemistry (which is intimately connected with the Illinois State Water Survey), and the Division of Industrial Chemistry.

The *Illinois Chemist* is a quarterly magazine published in the interests of the faculty, alumni, and students of the Department of Chemistry of the University of Illinois, under the auspices of the University of Illinois section of the American Chemical Society, the Chemical Club, the Alpha Chapter of Phi Lambda Upsilon and the Zeta Chapter of Alpha Chi Sigma.

The alumni of the Department of Chemistry of the University of Illinois number 397.

For the first semester 1915-16 there are 75 graduate students; further in the department of chemical engineering 11 seniors, 23 juniors, 34 sophomores, 32 freshmen; in the department of chemistry, 13 seniors, 15 juniors, 18 sophomores, and 13 freshmen. There are 10 general science students with chemistry as major course, and other students taking chemistry number 1901. Thus the total for the first semester 1915-16 is 2145.

Production of Nitric Acid from Ammonia by the Ostwald Process

The production of nitric acid from ammonia has become very important during the past year in Germany and is attracting now also considerable attention in this country (see, for instance, papers by W. S. Landis, this journal, Jan. 15, 1916, page 87, and March 1, 1916, page 260). The process by which ammonia is changed into nitric acid is usually called the Ostwald process, but in reality there are a number of such processes, all depending on the same principle and differing only in the design of apparatus and kind of catalyzer employed. We will retain the designation "Ostwald process" for the sake of brevity.

The Ostwald process was described in considerable detail in this journal, Vol. XI, page 438, 1913 (compare also Vol. XI, page 476, 1913). Some further interesting data on this process and its use in connection with the lead chamber process of making sulphuric acid are given in an article by G. Schüpphaus, in *Metall und Erz*, Vol. XIII, page 21, 1916.

When the imports of saltpeter were shut off by the war it was very important that Germany find other means of making nitric acid, not only to be used as such, but also for the manufacture of sulphuric acid. Most of the sulphuric acid made in Germany is made by the lead chamber process, in which nitric acid is necessary.

Up to the beginning of the war there was no process for the manufacture of nitric acid without the use of natural saltpeter which had found any considerable practical use in Germany. The fixation of atmospheric nitrogen by the electric arc had been limited to localities where cheap electrical power was obtainable and the oxidation of ammoniacal nitrogen by the aid of catalyzers (Ostwald process) was not used to any extent. With the latter reaction it was possible in the shortest time to develop a series of practical processes which all depend on the same principle but differ in the apparatus and nature of catalyzer. One of these processes

(Frank and Caro) was devised to be used in connection with the lead chamber process of making sulphuric acid. The apparatus is made by the Berlin-Anhaltische Maschinenbau A. G. in Berlin.

Impure ammonia liquor is first purified and then pure ammonia gas from this liquor is conducted to the catalyzer apparatus, where it is mixed with air and passed over the heated catalyzer forming nitric oxide and steam. From here it is conducted to the lead chamber.

In purifying the ammonia liquor it is first run into agitating tanks and as much milk of lime added as is necessary for the decomposition of combined ammonia. It is diluted until it contains 2 to 3 per cent ammonia, then pumped to the top of a separating column where the ammonia is gasified by steam. The ammonia-steam mixture is conducted from the top of the separating column to two water-cooled condensers, the liquid in the separator flowing to the bottom. From the condensers (which condense the water only) the ammonia gas goes to two soda washers containing soda lye solution of 30 deg. Baumé, which frees it from hydrogen sulphide, phenol, and other impurities which might affect the platinum gauze catalyzer further on. From the soda washers the pure gas is led to a gas container, which equalizes the varying gas pressure. From the container it is ready to be conducted to the catalyzing element. The operation of the pump which pumps the liquor to the separating column is arranged so that the gas container is always kept half full of gas.

The pure ammonia gas is now conducted to the element shown in detail in Fig. 1. and in the installation of three elements in Figs. 2 and 3. The usual method is to use three of these elements as a unit, running two of them at a time and saving the third for reserve, for a lead chamber system of 10,000 tons (metric) of 60 deg. acid annual production.

At the bottom as shown in Fig. 1, the ammonia gas enters on one side and air on the other. The air and ammonia before they meet each other and mix, pass through gage collars as indicated, whose diameters are so selected that a proper mixture of air and ammonia for burning will be obtained. For further adjustment a valve is placed in each line. The air and ammonia are mixed by a rotating aluminium plate, and pass then through a narrower iron wire screen.

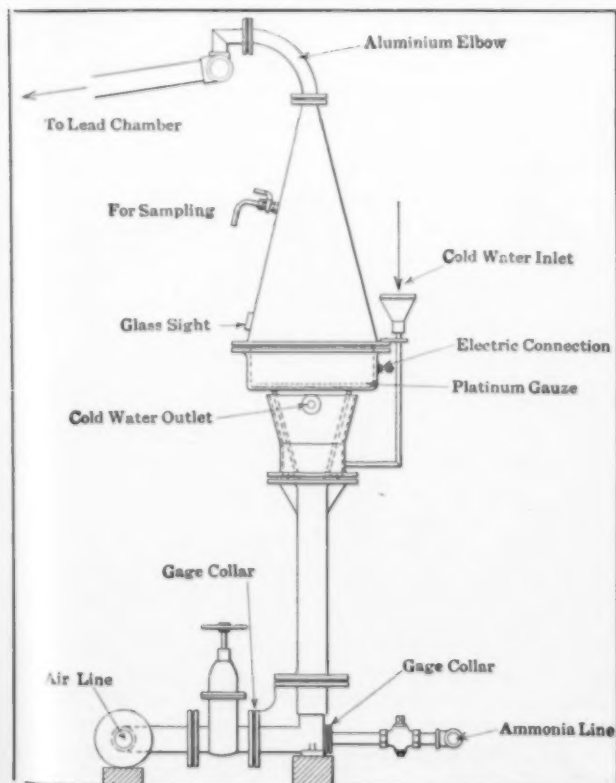
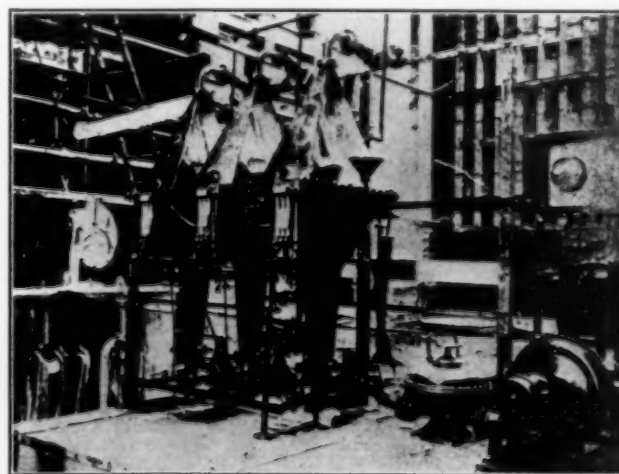
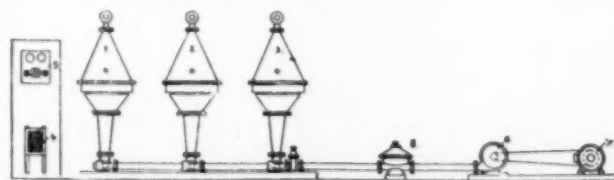


FIG. 1—SIDE VIEW OF CATALYZING APPARATUS



FIGS. 2 AND 3—UNIT OF THREE HEATING ELEMENTS

The air-ammonia mixture now goes to the platinum gauze, which is heated to about 700 deg. by electricity. At this temperature an almost quantitative conversion of the ammonia to nitric oxide and water takes place. The platinum gauze takes about 120 to 150 amp., at 24 to 26 volts for heating. In order to prevent as much as possible, breaking up of the ammonia by radiation and conduction from the glowing platinum gauze, before it reaches the hot zone, the lower half of the casing surrounding the gauze is cooled by water. For conducting away the oxide of nitrogen an iron hood is fastened to the burning chamber. This hood rapidly diminishes in cross section, and is lined with sheet aluminium on the inside, in order to prevent iron oxide particles from falling down on the platinum gauze. The elbow leading from the iron hood is also of aluminium.

The process is simpler if instead of impure ammonia liquor, pure sal-ammoniac containing about 25 per cent NH_3 is available. The lime tank, soda washer, etc. are then unnecessary and only the separating column need be used with two condensers and a gas container, also the frequent obstruction of the separating apparatus by lime does not occur.

The sal-ammoniac is best conducted to the separating apparatus in the following manner (Fig. 4). The sal-

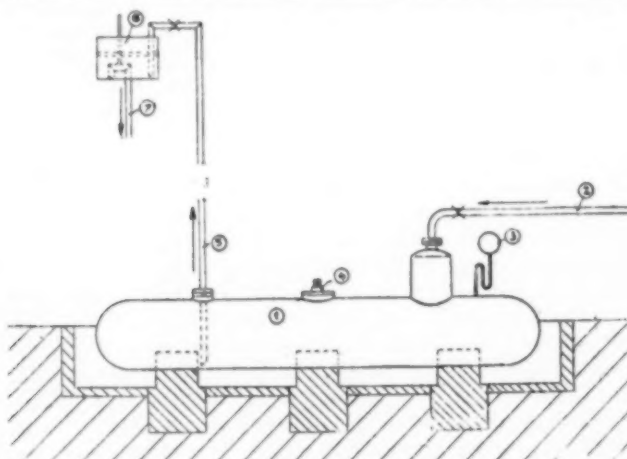


FIG. 4—METHOD OF DELIVERING SAL-AMMONIAC SOLUTION TO GASIFYING APPARATUS

ammoniac solution as needed is raised from tank 1 by means of compressed air into a small container 6 which has a connection 7 with the separating apparatus. In order to prevent evaporation of this solution as much as possible, a layer of oil is run in on top of the liquor and the tube 7 has a joint in the container as shown to prevent the oil from flowing into the separating apparatus. To break any syphon an open tube leads up from the joint as shown. The apparatus is very easily taken care of when pure sal-ammoniac is used and no special labor is required. A valve is supplied by the Berlin-Anhaltische Maschinenbau A. G. which automatically regulates the flow of ammonia solution, so that any attendance is unnecessary. The valve is regulated by the amount of gas in the container.

Once in a while the separating apparatus will become clogged up by iron oxide or hydroxide. This necessarily stops the flow of oxide of nitrogen to the lead chamber. On this account it is best to have a reserve apparatus.

The separating apparatus has a daily capacity (24 hours) of 5 cubic meters of liquid. If 2.5 per cent ammonia as in impure ammonia liquor water is used this means 125 kg. of ammonia gas; if 25 per cent ammonia is used as in sal-ammoniac it means that 1250 kg. ammonia gas per day may be generated, hence the desirability of using the latter.

The heating element should be placed before the head wall of the head chamber in the sulphuric acid plant. With this arrangement the formation of condensate in the 9 meter nitric oxide line is, however, not prevented in spite of good insulation. This condensate attacks the iron tube strongly and frequently causes shut downs. On this account the gas should be conducted to the head chamber in the shortest possible way. Stone pipe was adopted which projected in the chamber about 0.25 meter.

During the first trials, frequent interruptions occurred and at every interruption the chamber gases flowed back through the apparatus, passed the platinum gauze and escaped through the air ventilator. Through the contact with the chamber gases the platinum was rendered temporarily useless as a catalyzer. It was necessary to treat it with hot hydrochloric acid before re-using. This back flow was prevented by placing an iron plate trap in the main conducting line which is kept open when the flow is toward the chamber but closes when the flow starts to reverse.

Some of the nitric acid gas may be diverted from the main conducting line and condensed for use as a reserve in case of shut downs.

The Nitrate Industry in Chile

In a paper presented before the Second Pan-American Congress in Washington, D. C. (January, 1916), Enrique Cuevas gave a review of the status of the nitrate industry.

Caliche, the raw material from which the nitrate of commerce is extracted, was discovered in the great desert of northern Chile by the Indians some time in the seventeenth century. The first nitrate company was organized in 1812 with very crude reduction methods employed. The present era in the industry dates from 1855 with the introduction of steam as a means of heating and evaporating the solutions.

In 1873 the Peruvian Government assumed a monopoly of the nitrate lands and made grants in a careless manner. This led to much difficulty encountered by Chile when that country was left in possession of this area at the close of the Pacific war. However, titles have since been generally cleared up and beneficial laws enacted, covering not only the matter of land disposal, but of labor and other important questions.

According to the latest official report of the inspector general of the nitrate deposits, the zone of nitrate-bearing ground comprises 200,000 square kilometers, of which less than 3 per cent has been surveyed and prospected. In this surveyed portion alone there remains enough nitrate to supply the world for an additional 100 years, measured at the present rate of production. These calculations have been made on an extremely conservative basis, and take no account whatever of known areas of low-grade material.

The industry is divided into two principal operations: (1) mining and transportation of the crude material and (2) production of nitrate. Methods employed in both branches leave room for improvement. Under present practice, considering average value of raw material, wages, etc., the cost of producing commercial nitrate is estimated at 50 cents United States currency per quintal (101.44 pounds).

Trade specifications require a content of nitrate of sodium equal to at least 95 per cent. This is used as a fertilizer. The refined product, with over 96 per cent nitrate of sodium, is applied to manufacturing uses, such as glass, explosives, fusing mixtures, nitric acid, etc.

There can be no competition between Chilean nitrate

and atmospheric nitrate under any conditions which may be foreseen at present. The deposits of the great Pampa Salitrera (nitrate plain) are too vast and the business of manufacturing and marketing the material is too well systematized, whereas atmospheric-nitrate manufacture exists under too many limitations.

A natural reduction in nitrate production has followed the outbreak of the European war, many of the important consuming markets having been cut off.

The author has appended detailed data regarding nitrate production, method of transacting nitrate sales, results of experiments showing the advantages of using nitrate of sodium as a fertilizer, with special reference to crops raised in the United States, and other items of value covering the entire field.

The Turpentine Industry in the Southern States*

BY CHARLES H. HERTY, PH.D.

A railway trip through the coastal plain of the South Atlantic and Gulf States, from North Carolina to Texas, shows on every side fallen and charred remnants of trees, stumps innumerable, and occasional huge piles of sawdust. It is a desolate scene in those sections where agriculture has not yet been developed. It represents the destructive path of the naval-stores industry, followed more or less closely by that of lumbering, through that rich, natural heritage of long-leaf pine forests which originally covered completely this entire portion of the country.

From these forests the world has received its chief supply of spirits of turpentine and rosin, averaging in value in recent years some \$40,000,000 or \$50,000,000 annually. Yet in the production of this great crop only a very few have received for their toil more than a bare livelihood. The great mass of the turpentine operators have toiled throughout the years in rugged earnestness, in robust health from the out-of-door life in the pine forests—but always on the outer edge of developing civilization, with few of the comforts and conveniences

*A paper presented at a joint meeting of the Franklin Institute and the Philadelphia Section of the American Chemical Society.

of life, indifferent to the utter lack of efficient business methods in their operations, and strongly wedded to woods practices which have been handed down from generation to generation as they steadily moved from North Carolina toward Texas.

If the traveler, however, should leave the main lines of travel in Florida or the more westerly states, and by tram or team reach some of the more remote sections, he would find beautiful virgin forests of this same long-leaf pine, the rich brown trunks of the trees, free from low-lying limbs, bearing aloft rich crowns of green, and firmly rooted below in a soft carpet of the same hue, formed by the "wire grass" which abounds throughout this territory.

Will the operator, in the exploitation of these remaining forests, profit by the demonstrated inefficiency of past methods? Can he change his attitude of thought toward the living tree on which his operations are based? Is he willing to place himself in line with all other lines of modern industrial life, which have realized, or are beginning to realize, that true progress in any industry must be based, not upon individual opinion or hereditary teachings, but upon scientific research and constant striving for greater efficiency?

Upon the answer to these questions depends largely the future of the naval-stores industry. This is not a matter for indefinite proceeding along inefficient lines; the actual life of the industry is threatened, for the once-considered inexhaustible forests are rapidly disappearing. At the present rate of destruction the end can be fairly well forecasted, especially since no effort is being made toward reforestation.

It was natural that destructive methods should have characterized this industry, for the early settlers in eastern North Carolina found forests of long-leaf pine everywhere. Clearance was necessary for agriculture, crops had to be grown, lumber was needed for industry, homes had to be built, and so the work of destruction began.

It was immediately recognized that this tree, when wounded, is a prolific producer of an oleoresin, "crude turpentine." Furthermore, the rich resinous wood, when heated out of contact with air by piling in heaps and covering with earth, gave off a rich distillate of tar,



FIG. 1—CUTTING THE BOX

FIGS. 1 TO 3—BOX SYSTEM

FIG. 2—CORNERING THE BOX

FIG. 3—CHIPPING THE FIRST STREAK
ABOVE THE VIRGIN BOX

which could be boiled down to a pitch. These products, tar and pitch, were much needed for the wooden ships with their extensive rigging, at that time universally in use; and so along with agriculture, with its yearly crops, there developed the naval-stores industry with its constant output of immediately marketable products.

The method of conducting the industry called for no plant other than the forests, and so when the yield of the trees began to decrease after two years of operation, new tracts were opened, and the industry began its march southward, from North Carolina into South Carolina, thence into Georgia and Florida, and then rapidly expanding into the Gulf States, though on a smaller scale.

In the early days in North Carolina no effort was made to separate the crude turpentine by distillation into its constituents, spirits of turpentine and rosin, the gum being shipped to Northern cities or to England for such manufacture. In the early part of the past century, however, this manufacture was transferred to the woods, iron stills being at first employed, which later were replaced by the more efficient copper stills such as are used to-day for this purpose.

In the woods, however, there was no corresponding advance in methods of operation, with the exception of slight improvement in the tools employed. Thus for more than a hundred years the method of wounding the tree and collecting the gum remained the same throughout the turpentine belt.

The normal routine on all turpentine farms consisted of the following operations:

"Boxing."—In the winter negro laborers, under the direction of a white woodsman, cut "boxes." The box was an elliptical cavity cut in the base of the tree, usually just above the junction of a prominent root with the trunk of the tree. It served to collect the gum which flowed during the warmer months from the scarified surface above. The tool used in cutting this box was a very long, narrow axe, the negroes developing consummate skill in the use of this "box axe." The standard dimensions of the box were 14 in. width, 7 in. depth, and 3½ in. from the outer wood toward the center of the tree. The number of boxes per tree was increased from one to four, and occasionally five, according to increasing diameter of the trees.

"Cornering."—Box cutting was followed by "cornering." This consisted of removing two triangular chips from immediately above the box by means of the usual wood-chopping axe. The function of cornering was to provide smooth surfaces to direct the flow of the gum into the box.

"Chipping."—As vegetation became active in early spring the work of scarification of the trunk of the tree began, and continued weekly for eight months. The repetition of this process was necessary, as the flow of gum, greatest during the first three days following the fresh chipping, practically ceased after one week. The tool employed in chipping, called a "hack," was a stout U-shaped steel blade attached by a metal shank to one end of a round wooden handle. This handle carried on its other end a heavy iron weight which gave momentum to the free arm stroke used to draw the blade through the bark and outer sapwood. A slightly modified form of this tool, called the "puller," was mounted on a much larger handle, with no iron weight attached, and was used for the higher reaches of the third and fourth year of scarification.

"Dipping."—At periods of four to five weeks, when, in the judgment of the woodsman, the boxes showed an average filling, the gum was removed into buckets by a broad, flat, spear-shaped tool, called a "dip spoon." Bar-

rels placed at convenient distances in the woods received the gum from the buckets, and were then hauled to the "still" for distillation.

"Scraping."—As the chipping season progressed not all of the gum found its way to the box, for as crystallization of the gum began some of this mass remained sticking to the exposed surface of the tree. At the close of the chipping season this accumulated resinous mass was scraped from the trees, thus giving the name, "scrape," to the product. Its content of spirits of turpentine was much lower than that of the gum from the boxes.

"Raking."—With the completion of the scraping, the final operation was the protection of the trees from the ground fires which prevail throughout the turpentine belt in late winter when the dead wire grass is burned. Such protection, "raking," was effected by means of a common hoe, all combustible material, chips, pine needles, and dead grass, being removed to a distance of about 2 ft. from the base of the tree.

This completed the year's operations in the woods, and the cycle was then renewed from year to year.

The severe strictures on the wastefulness of the industry spoken by the German technologist, Otto N. Witt, led to the determination on the part of the writer to investigate whether or not this criticism was deserved. Correspondence with men familiar with the industry, and a brief visit to a turpentine farm in South Georgia, afforded ample proof that conditions were even worse than had been depicted.

With such waste prevalent, could not something be done to improve the situation? Here the methods of work learned through research in a chemical laboratory asserted themselves. A search of the literature was begun and made as comprehensive as possible. The results of this study and of observations in the woods made clear the fact that the great evil of this industry, that which more than all else was responsible for the waste and destruction, was the cutting of the "box" in the base of the tree. This deep cavity, located just where the strain was greatest, caused many of the trees to fall in even slight windstorms. It constituted a great source of danger during fires, especially after turpentine operation had ceased and the tree no longer was protected by the annual "raking." The decreased vitality of the tree, due to the severe wound, led in many cases to easy attack by injurious insects. Such evils were easily noticeable, but others, less readily seen, were found upon closer study. With a receptacle at a fixed point, while the distance between the receptacle and the freshly-chopped surface increased regularly from week to week, opportunity was thus afforded for increasing loss of the volatile oil by evaporation, for coloration of the rosin by absorption of oxygen from the air under the influence of sunlight, and for waste in dripping outside the box. It seemed reasonable, moreover, that this severe wound would so decrease the vitality of the tree as to cripple, at least to some extent, the power of the tree to produce crude turpentine. The "box," therefore, should be the primary point of attack in any effort to conserve these forests.

To overcome the evils of the "box," a substitute receptacle must be provided which should inflict but a slight wound in placement on the tree; should be capable of removal at convenient intervals to a point just below the chipping surface; should be extremely simple in its construction in view of the gummy character of the product it was to receive; easy of operation, because of the unskilled labor which would use it; and cheap, if hopes were to be entertained of its commercial introduction by those who are abundantly satisfied with existing methods and fully convinced that

no better could be found—an unfortunate state of mind, in these days of progress.

The literature of the French system of turpentineing was then studied, and the records of the Patent Office were thoroughly searched. Nothing, however, was found quite free from objections to its ability to meet the above requirements, especially as applied to the system of chipping as practised in the Southern States. In the light gained from this study, however, a substitute was devised, consisting of a simple cup suspended, through a hole near its rim, on a common nail. Into this cup the gum was to be directed by two shallow galvanized iron troughs or gutters, to be inserted about $\frac{1}{4}$ in. deep by one of their long edges in correspondingly shallow inclined cuts across the scarified surface of the tree.

With this apparatus provided, and again following the procedure of laboratory research, preliminary experiments were begun, during the summer vacation of 1901, in the forests of southwest Georgia, near the town of Statesboro, on timber provided, after much persuasion, by some of the leaders of the industry in Savannah, Ga., who viewed their concessions with an eye of infinite skepticism.

The results of these preliminary experiments were the thorough demonstrations of the efficiency of the apparatus, a deeper grasp of the problem to be solved, a genuine sympathetic interest with the personalities of many employed in the industry, and much knowledge of the habits of the pine. It was completely demonstrated that the dark color of rosin produced under the box system, after the first year of operation, was not at all due to physiological changes in the pine, but solely to the method of collecting the gum. Under this system opportunity was offered for increased oxidation and for absorption of the deeply-colored gum coating the exposed surface, formed by the shipping of previous years. This was important, as the commercial value of the rosin decreases as the depth of color increases.



FIG. 4—CUP SYSTEM; GUTTERS AND CUP IN POSITION

The United States Bureau of Forestry, hearing of the proposed preliminary experiments, tendered the writer a collaboratorship in order to secure publication of the results. The experiments were so full of promise that it was agreed that the work should be promptly resumed at the opening of the next season, with field experiments on a commercial scale, under the auspices of the Bureau of Forestry. Accordingly, the experiments were begun in February, 1902, on the turpentine farm of Powell, Bullard & Company, a well-known firm operating in southeast Georgia, near the town of Ocilla.

For these experiments the following policy was adopted at the outset:

1. The timber was to be provided by the firm, the cups and gutters and cost of installation by the bureau.
2. The labor was to be none other than such as was employed in the regular work of the farm.
3. The experiments were to be restricted solely to the "box" question and the practicability of the substitute cup and gutters. Therefore the work of chipping, dipping and scraping should be conducted in the normal way.
4. Four sets of comparative experiments were to be conducted simultaneously, one on virgin timber and three on boxed timber which had already been operated respectively one, two and three years. This would determine, so far as possible in one year, the influence of the box on the timber and on the income of the operator.
5. The results should be taken from the records of the company, whose statements would be readily accepted by all other operators.

So far so good. Then troubles began. The manufacturer, delayed in his work, did not deliver the equipment until the chipping season was nearly at hand. This led to a shortcoming, undreamed of at the time, and which in after years caused the loss of many thousands of dollars, but this will be discussed later.



FIG. 5—CUP SYSTEM; UNBOXED TREE WITH CUP AND GUTTER IN POSITION AT END OF FIRST YEAR'S CHIPPING, SHOWING CORRECT POSITION



FIG. 6—CUP SYSTEM; "DIPPING" THE CUP

Next, labor troubles were unexpectedly encountered. The negro laborer proved even more conservative than the white operator and woodsman, and assumed the remarkable attitude that the "flower-pot" method of making turpentine was more properly the work of women and children, and not suited to the dignity of full-grown men. This may be difficult of belief, and it was strange in the light of later developments, but it proved a serious obstacle for some time. By dint of patience, tact, and kindly reasoning this trouble was at last overcome sufficiently to enable a beginning of work in the woods with three laborers, but up to the very moment of actual handling of the axe the chagrin and mortification of those three negroes, too inefficient for the regular box-cutting squad, were comical, though the situation had its serious side in that the whole question of the carrying out of the experiments was at stake in the successful solution of this labor difficulty.

It is sufficient here to state that in a short while the problem was completely solved, and as success in the experiments became more and more marked the comical picture then became the rather haughty air and proud demeanor of those who gleefully dubbed themselves "cup niggers"!

To return to the experiments: three crops were selected, consisting each of 10,000 boxes, the unit of operation. These three had already been under operation one, two and three years respectively. On one-half of each of these crops cups and gutters were installed near the point where the chipping would begin. On the other half the gum was collected in the normal way, in the box, at the base of the tree. These experiments would determine the practicability of the equipment at varying heights on the tree; the quality, as to color, of the rosin produced from gum collected under the two systems, and would give some information as to relative waste from evaporation, etc.

The main interest, however, centered in the experiment on virgin timber, where the two systems could be

put into operation under fully equal conditions. For this experiment a tract of timber of fair average quality was selected by the firm just outside of the town.

To insure accuracy of the experiment, this timber was carefully and repeatedly cruised by experienced woodsmen, and a division made as to location of cups and boxes respectively. In this division it was decided to alternate the "drifts" (subdivisions of a crop) of cups and of boxes. This also furnished more uniform weather conditions in working the two halves. The entire crop was to be chipped by one man, and the dipping was to proceed every three weeks, simultaneously in the cupped and boxed halves of the crop, the gum to be collected in different sets of barrels. The presence of varying trash and water would render inaccurate the results from measuring or weighing the gum. Therefore it was distilled and record kept of the number of gallons of spirits of turpentine obtained from each lot, and separate sales made of the rosin produced. No difference in quality of rosin was expected or found here. As the distance of flow of the gum was the same in each set, loss of spirits of turpentine by evaporation was equalized.

All precautions were taken so that whatever difference of results might be found in the yields from the two halves could be ascribed to no other factor than the influence of the severe wound caused by box cutting on the productive power of the trees. The advancement of the idea that it decreased productive capacity had met with hoots and jeers on all sides, and here in this crop, it was felt and stated without the least effort of repression, would be demonstrated the superiority of the judgment of the "practical" man over the theoretical college professor.

The work of installation began. Two flat faces meeting in a central line were cut with common axes to adapt the round tree to the straight-edged gutters, two laborers with broadaxes made across these plane surfaces the incisions for the gutters, which were promptly inserted by another group of laborers, the upper gutter reaching just to the center of the face emptying into the opposite gutter equally inclined, running about 1 in. lower and extending about 2 in. beyond the angular center of the face, to provide a suitable hanging of the cup into which all of the gum dripped. While awaiting the arrival of the cups and gutters, the box-cutting squad and the "cornerers" had been gleefully at work in the other half of the crop.

With the respective receptacles provided and installed the work of chipping began—and the race was on. The detailed results are given in Table 1.¹

¹The tables throughout this paper are from Bulletins 40 and 99 and Circular 34 of the U. S. Forest Service.

TABLE I—FIRST-YEAR CROP—DIPPINGS

Number of Dipping	Date of Dipping	Number of Chippings	BARRELS OF DIP OBTAINED		SPIRITS OF TURPENTINE ON DISTILLATION (GALLONS)		EXCESS SPIRITS OF TURPENTINE (GALLONS)	
			Boxes	Cups	Boxes	Cups	Boxes	Cups
1	April 14	3	91	117	101.6	84.3	17.3	
2	May 5	3	91	101	111.0	130.5		19.5
3	May 26	3	12	14	136.8	178.3		41.5
4	June 16	3	12	17	143.3	191.2		47.9
5	July 7	3	12	14	142.4	175.2		32.8
6	July 28	3	10	12	115.2	141.7		26.5
7	Aug. 18	3	10	11	108.6	126.6		20.0
8	Sept. 8	3	8	10	86.1	105.9		19.8
9	Sept. 29	3	7	9	80.0	106.0		25.2
10	Nov. 4	5	110	12	110.9	145.6		34.7
Total		32	101	121	1,134.7	1,385.3	17.3	267.9

¹Including rosin from box cutting and cornering.
²Including rosin from placing cups on trees.
³Boxes dipped after trees have been scraped.

The unexpected shortage from the cups on the first dipping led to great rejoicing among the box supporters, and to undoubted apprehension on the part of the solitary backer of the cups. The second dipping, however, altered the situation, and by the last of June the victory for the cups was so complete that all were converted. The beginning of the end of the box system had been reached. From this point on all went well. Labor was anxious to enlist, enthusiasm had supplanted scoffing, and now the chief effort of the original cup backer was to guard against possible inflated results, due to some over-zealous convert, which results might not be justified by the facts in the case, for in spite of convictions formed in advance of experiment it was, as in all research, the truth which was sought.

Several years passed, much thought was expended, and many experiments were made before the true interpretation of that shortage on the first dipping was obtained and its remedy provided. This will be discussed later.

Meanwhile the distillation of the gum from the second, third and fourth year crops showed uniformly high-grade rosin from the cups, as contrasted with the low-grade rosin from the corresponding boxes, and the equipment proved itself readily adaptable to the increasing heights of chipping.

The results of net rosin sales from all four crops are given in Table II.

TABLE II—SEASON'S RECORD OF NET ROSIN SALES

Half Crop	From Dip	From Scrape	Total	Excess Net Sales	Per Cent Excess Net Sales, Cupped Trees
First year:					
Cups	\$401.72	\$47.72	\$449.44	\$85.51	23.50
Boxes	328.40	35.53	363.93		
Second year:					
Cups	266.34	49.25	315.59	144.13	84.64
Boxes	104.51	66.95	171.46		
Third year:					
Cups	171.27	27.44	198.71	132.65	200.80
Boxes	39.49	26.57	66.06		
Fourth year:					
Cups	167.33	29.23	196.56	132.56	207.13
Boxes	36.09	27.91	64.00		

The experiments with the second, third and fourth-year crops were discontinued at the end of the year, having served their purpose. The working of the virgin crop, however, was continued two years longer. The complete results for the three years' operation of this crop are given in Tables III, IV, and V.

That the distribution of the timber in this virgin crop had been well equalized was shown by measurements of diameters of all trees in the crop and by a determination of the average number of cups or boxes per tree throughout the crop.

As the work progressed, careful record of the dead and down trees were made in each half. The count at the end of the three-year period is shown in Table VI.

During the chipping season portions of some of the chipped surfaces became unproductive, locally termed "dry face." The results of the measurement of the extent of "dry face" in the two halves of the crop showed an excessive amount in the boxed half at the end of the first year. From that time on the amounts, while increasing in each, showed less striking difference. Evidently the cause of increased "dry face" in the last two years lay more and more in the chipping, and this observation led to later valuable experiments on comparative yields from lighter chipping.

The results of the first year's experiments were communicated to the turpentine operators at their annual convention. Much interest was aroused and some enthusiasm. The next few months, however, proved an

TABLE III—SPIRITS OF TURPENTINE FROM HALF CROPS

Year	CUPS			BOXES			Excess from Cupped Half Crop, Gallons	Net Price per Gallon at Time of Operation Cents	Value of Cup Excess
	From Dip, Gallons	From Scrape, Gallons	Total, Gallons	From Dip, Gallons	From Scrape, Gallons	Total, Gallons			
First	1,385.3	205.0	1,590.3	1,134.7	153.7	1,288.4	301.9	40	\$120.76
Second	1,103.5	165.0	1,268.5	705.2	226.6	931.8	336.7	45	151.52
Third	781.3	136.0	917.3	536.1	190.5	726.6	190.7	45	85.82
Total	3,270.1	506.0	3,776.1	2,376.0	570.8	2,946.8	829.3		\$358.10

TABLE IV—NET SALES OF ROSIN FROM HALF CROPS

Year	CUPS			BOXES			Excess from Cupped Half Crop
	From Dip	From Scrape	Total	From Dip	From Scrape	Total	
First	\$401.72	\$47.72	\$449.44	\$328.40	\$35.53	\$363.93	\$85.51
Second	266.34	49.25	315.59	104.51	66.95	171.46	144.13
Third	171.27	27.44	198.71	39.49	26.57	66.06	132.65
Total	\$901.20	\$167.61	\$1,068.81	\$585.58	\$199.31	\$784.89	\$283.92

TABLE V—SUMMARY OF GAIN FROM CUPPED HALF CROPS

Years	Spirits of Turpentine	Rosin	Total
First	\$120.76	\$85.51	\$206.27
Second	151.52	128.62	280.14
Third	85.82	69.79	155.61
Total	\$358.10	\$283.92	\$642.02

TOTAL VALUE OF PRODUCTS FROM THREE YEARS OF OPERATION

Cupped half crop	\$2,688.55
Boxed half crop	2,046.53
Gain from cupped half crop	\$642.02 = \$1,284.04 per crop

TABLE VI—RECORD OF DOWN AND DEAD TREES

	NUMBER OF TREES BLOWN DOWN		NUMBER OF TREES DEAD	
	Boxed	Cupped	Box	Cupped
In 1 year	8	3	35	16
In 2 years	60	34	139	93
In 3 years	78	44	217	150

interesting testimonial to the "follow-up" policy of the wise advertiser, for, in the three-month period spent in arranging for the manufacture of the equipment at a reasonable cost and in the preparation of an account of the experiments for publication as a government bulletin, interest in the matter completely disappeared. It was only through the most persistent efforts that interest was sufficiently re-aroused, in those at one time enthusiastic, to assure the commercial utilization of the rather limited output of the cup factory.

The first season's use of cups by the operators assured the future, the results obtained more than confirming the experimental results of the previous year. Instantly the demand increased; prejudice slowly gave way; the quality of the cups was improved with increasing experience at the factory; timber owners made concessions in price of leases, provided cups instead of boxes, eventually stipulating that timber could not be worked if box cutting was the intention, and labor throughout the territory became familiar with and enthusiastic about the new method. Thus was the box system, with its attendant losses, replaced by the more efficient-cup system. To-day box cutting is practically a thing of the past, while many forms of cups, to suit

individual requirements, have become every-day articles of commerce.

From the outset, railway officials of the Southern States, keenly alive to the welfare of the territory tributary to their lines, were strongly sympathetic with this movement, and by their prompt and intelligent handling of the question of freight rates on the equipment, facilitated greatly the universal introduction of the new method.

To encourage the adoption of the new system, the Forest Service adopted the wise policy of offering, free of cost to the operators, the services of the writer in inaugurating the work on a turpentine farm. Never to be forgotten was the first experience in this work of instruction, when, on a cold, drizzly February day, at a south Georgia sawmill, there was handed over for instruction a group of sixteen young negro convicts, in characteristic garb and utterly devoid of any knowledge of turpentine operations. The situation seemed impossible and hopeless, but the future of the work was at stake. Fortunately, experience gained in years of teaching in the classroom came to aid. The setting was entirely changed, but the methods of pedagogy were applicable and necessary. The effort succeeded. After such an experience all others were easy.

The "practical man," however, had his inning, for a little later, working in timber near the Gulf Coast of Florida, it was found that such timber was so tough that it was impossible to make smooth, flat faces on the tree for the gutters with the ordinary axe employed. After a long day of struggle, with defeat clearly ahead, the turpentine operator suggested the use of the broad-axe for this purpose. The experiment was tried and immediately succeeded. Later another step forward was taken by the suggestion of another operator that in hewing with the broadaxe the bevelled side of the edge be placed next to the tree. This was revolutionary from an axeman's point of view, but it was tried and its advantages were immediately noted, for there was no difficulty in forcing the axe to the surface at the base of the cut, thus saving the tree useless wounding and so increasing the speed of operations that in a little while it was possible, with an equal force of laborers, to install three crops of cups while one crop of boxes was being cut. Such details may appear trivial, yet each had its influence on the rapid introduction of the system.

As reports began to arrive concerning commercial experiences with the system all agreed on increased yield, but all agreed likewise on the unusually large number of chippings required to fill the cups with gum at the beginning of the season, especially when compared with boxes on similar timber near the cupped tree, the capacity of cup and box being the same. After this first dipping the superiority of the cup system readily showed itself in largely-increased yields. Here was a recurrence of the mortifying experience with the first dipping of the virgin crop in the experiment at Ocilla. What could be its explanation? How could the trouble be overcome? Various suggestions were made and numerous experiments tried by men of all types in all sections, but without success in overcoming this chief defect in the system.

A few years later the writer had opportunity to visit Prof. A. Tschirch in his laboratory at Berne, Switzerland, and there learned his views concerning resin flow, views based on the results of experiments on many pines in the neighborhood. According to Tschirch the resin ducts, found scattered throughout the wood of a normal pine, contain a resin which is formed as a result of natural life processes in the living tree. Such a product is, therefore, a purely physiological product, and

such ducts he designated "primary resin ducts." These yield only a small quantity of crude turpentine when the tree is wounded. Immediately after the wounding, however, there begins in the outer fresh wood the formation of a very large number of resin ducts, both above and below the wound, forming an anastomotic system, which pour out crude turpentine in great quantity as a healing balsam over the wound. Such an exudate is a pathological product, and the ducts producing it he termed "secondary resin ducts." These extend 4 to 5 in. above the wound, requiring four to five weeks for their full development.

In the light of this knowledge the explanation of the excess yield of the boxes over the cups on the first dipping was simple. When the boxes were cornered a full-width, V-shaped surface was formed above which the secondary resin ducts formed in abundance during the several weeks which elapsed before the chipping season began. Then when the first chipping was made the cut traversed secondary resin ducts along its full length and a maximum yield was obtained.

On the other hand, the late arrival of the cups for the experimental work made it necessary to begin chipping immediately afterward. The secondary resin ducts had not fully formed during this brief interval, and there was a correspondingly low yield of crude turpentine, which, however, rapidly increased later as the ducts increased.

Again, in explanation of the same difficulty experienced by operators who placed their cups on the trees many weeks in advance of the chipping season, it must be remembered that the flat faces for the gutters were then being made on the tree by the broadaxe. The cutting of a straight-edged tool into a round tree exposed the fresh wood above in the form of two curved lines, meeting at the center of the cut surface. Again, the secondary resin ducts formed, but following the outline of the cut. When, therefore, these trees were chipped, only about half of these ducts, those near the center, were traversed by the downwardly-inclined stroke of the back. Hence a flow of gum far below that in the box system, but again rapidly increasing after the first full-width cut formed by the first chipping.

This suggested a simple method for overcoming the losses encountered during the first six or eight weeks of operating under the cup system, namely, the placing of the gutters on the trees in winter should be followed immediately by one full-width chipping and the trees allowed to stand, without further chipping, four or five weeks. Opportunity would thus be given for full formation of the secondary resin ducts along the full width of the chipping surface, as in the box system.

These views were laid before a number of operators using the cup system, and they were requested to try the modified method on some of their timber during the next winter. They agreed; the experiments were carried out, and in every case the cure for the evil was found to be complete, cups so placed yielding a greater amount on the first dipping than boxes, or than cups placed without the one winter chipping. Conservative estimates made by experienced operators place the total annual gain from this slight modification of woods practice at not less than \$500,000. Could there be asked a better illustration of the value of pure university research, as was that of Tschirch, for efficient industrial operation?

With the future of the cup system assured, attention was next turned to the relative yield of crude turpentine with reduced wounding of the tree in chipping. These experiments were conducted near Green Cove Springs, Fla.

In order to interpret the results clearly, all trees were

cupped, and one of the crops chipped to normal depth, 7/10 in. into the new wood, the thickness of the chip being such as to carry for chipping up the trunk at the normal rate. This crop was designated A.

In another crop, designated B, the depth of the chipping was reduced from 7/10 in. to 4/10 in., all other conditions being identical with the standard crop A.

In a third crop, designated C, the thickness of the chip was so reduced that the same elevation on the trunk would be reached in four years as was reached in three years in crop A, all other conditions being alike in the two crops.

Finally, in a fourth crop, designated D, no tree under 10 in. was worked; the minimum diameter for trees bearing two cups was raised from 12 in., as in crop A, to 16 in., and, finally, no tree bore more than two cups, regardless of its larger diameter. In this crop the chipping was the same as in the standard crop A.

The results of the four years of work on these crops are given in Table VII.

TABLE VII

Crop	DIP		SCRAPE		
	Yield Pounds	Increase Per Cent	Yield Pounds	Increase Per Cent	Decrease Per Cent
A	206,235		47,742		
B	211,911	2.75	44,838		6.08
C	214,503	4.01	39,775		16.69
D	279,260	35.41	33,915	12.93	

The marked success of these experiments led to a further experiment for one year, in which was compared with a standard crop, such as A above, the yield from two crops, designated G and H, in which both modifications of chipping, shallow and thinner cuts, as in B and C above, were combined. The results are given in Table VIII.

TABLE VIII

Crop	Number of Cups	Number of Chippings	Yield of Dip, Pounds	Increase, per Cent
Wallkill Turpentine Company	9,880	35	90,094	
G	9,880	35	124,292	38
H	9,880	35	121,474	35

This was the way clearly pointed out for more conservative treatment of the trees, the result being largely increased yields.

Are further experiments on the reduction of the wound in chipping justified? This is a difficult question to attempt to answer. Certainly there is a limit to which such reductions can be carried, beyond which financial loss will result, under existing conditions of cost of stumpage and wages of labor. If the tree is not wounded, crude turpentine is not produced; if it is girdled, the tree dies. Somewhere between these extremes lies the most efficient operation. From the results already mentioned it is evident that past practice in chipping has been on the side of too excessive wounding. Whether or no the limit should be further reduced can be determined only by experiment.

One abuse, however, has arisen in connection with the spread of the cup system, namely, the general practice of cupping very small trees. Such trees were not brought into operation under the box system, as they were too small to receive a box, but they could be cupped with ease. Two strong objections hold against this practice: First, the trees of the future naval-stores industry are being destroyed, a well-marked case of child-labor abuse for which there is no legislative cor-

rection. Second, the judgments of the leaders of the industry agree that the operation of such small trees is unremunerative in itself, yet often producing sufficient crude turpentine to seriously depreciate the market value of that produced from the larger trees.

Much has been spoken and written by these leaders against the practice, but still it continues. Is not experiment advisable here? The following is suggested, and it is hoped that the suggestion will receive the consideration of the United States Forest Service. An investigation is needed of what is the actual yield from a crop of 10,000 of these very small trees during a period of three or, better, four years of operation. Such an investigation would give facts where now mere opinion prevails. The experiment would not be costly, because it could be carried out in connection with the regular operations of a turpentine farm. It would require only efficient supervision; the dipping from the small trees to be kept separate from those of unquestioned size, say 10 in. and over, in diameter; the yields from the two lots compared, and the results published for the benefit of all. Such a publication would constitute a valuable contribution to the literature of this subject, and such facts would carry far more weight than any amount of spoken or published criticism.

Leaving now questions connected with woods practice, let us follow the barrels of gum to the distillery, or "still," as it is uniformly called. This manufacturing plant is exceedingly simple, and, as a rule, roughly built, the rapidly-shifting character of the industry not justifying more pretentious housing. A large copper kettle, the "still" proper, is set in brick masonry above a firebox in which pine wood is burned. Eight to ten barrels of the gum, mixed with chips, dirt, and some water, constitute a charge, the distillation of which requires from three to four hours.

The kettle is connected by a removable "still head" to a coiled copper worm, set within a large wooden tank, the condenser, into which cold water flows or is pumped at the bottom, cooling thus the hot mixed vapors of steam and spirits of turpentine in the condenser coil. The heated water is led off by an overflow or is partly used by running along a narrow trough leading from the top of the condenser to a small, funnel-shaped opening in the lower part of the still head, and emptying into the still and on to the boiling gum below, the steam thus generated aiding materially the separation of the volatile spirits of turpentine from the non-volatile resin.

The proper regulation of this flow of water has been generally determined by the sound produced by the boiling mass heard at the mouth of the condenser. Recently the use of inset thermometers for the purpose of controlling the distillation has largely increased.

The condensed liquids, flowing from the mouth of the worm, separate at once in the receiving vessel into two layers. The lighter spirits of turpentine is pumped into large storage tanks or is dipped into oak barrels, which have been thoroughly coated inside with glue. It is now ready for marketing. When the volatile oil is practically all removed, the still head is taken off, and the chips are skimmed. In the case of virgin dip this skimming is done as soon as the gum melts and before distillation begins.

Finally, when all water has boiled off, a necessary precaution to prevent the rosin being opaque, the molten rosin is allowed to flow from the still through a tail pipe, leading from the bottom of the still, to two strainers placed the one above the other. The upper strainer consists of coarse wire gauze, and retains unskimmed chips. The lower strainer, of fine brass gauze over which are placed layers of cotton batting, retains

the dirt and smaller portions of trash. From these strainers the rosin flows into a long wooden vat, from which it is promptly dipped into barrels, where, upon cooling, it solidifies and is then ready for shipment.

Crude as the method appears to the casual observer, nevertheless careful study of this system as compared with the much more expensive systems in France has convinced the writer that, given a good stiller, equally good results are obtained by this very inexpensive outfit. Of course, the presence of the personal element, as represented by the stiller, is always a risk in manufacturing operations, and it would seem to be a needless risk in the light of its complete elimination in the French system of "mixed injection," where heating is effected partly by free flame and partly by steam; where water vapor is furnished both by inflowing hot water and by direct injection of steam, and where operations are controlled entirely by the thermometer. Such plants are not expensive and are very simple in operation.

The suggestion has recently been made that this industry would be placed on a much more efficient basis if the smaller stills in the woods were done away with, the gum hauled in tank cars direct to a central distillery, advantageously located, and there distilled. This suggestion contains many thoughts which justify the belief that here lies the way to the next decided step forward in the evolution of this industry, if questions connected with transportation can be properly worked out.

Undoubtedly there is much waste at the present small distilleries. Important matters concerning utilization of by-products cannot be properly handled under the present system. Much demoralization of labor arises from the still being near the turpentine camp.

On the other hand, the handling of crude turpentine in sufficient quantities at a central distillery would justify the presence of the most efficient forms of stills and of labor-saving devices common to all handling of material in large quantities.

Of possibly still greater importance is the fact that operations on such a scale would justify the employment of competent chemists, who, in addition to the careful control of the operation of the distillery, could supervise the manufacture of rosin oil directly from the molten rosin, of the various commercial articles into which such products enter, and who could by systematic research find new uses for and new transformations of the various products, thus guiding the industry to wider fields of application, and enabling it to more fully keep abreast of that progress characteristic of all industries which wisely make use of the services of well-trained chemists.

University of North Carolina,
Chapel Hill, N. C.

Course in Gas Manufacture and By-Product Recovery at Johns Hopkins University

The Department of Engineering of the Johns Hopkins University has organized and is now giving a course in gas manufacture and by-product recovery for such students of engineering or chemistry as desire to prepare themselves for entering this important field of industry. The work may be elected during the fourth year of the courses in mechanical, electrical or civil engineering, and may be pursued as graduate study. The course is also open to graduate students in either chemistry or engineering, and may be elected by such fourth-year undergraduates in chemistry as are able to qualify for the work. It is highly desirable that those taking this work should have completed three years of undergraduate work in one of the branches of engineering.

This course involves essentially the study of the dis-

tillation of carbon and the utilization of all the products of the process. It deals with the principles underlying the gas industry and the production of most of the chemicals used in the industries of the world. The work is taken up in both lecture room and laboratory, for which special equipment is being provided.

The following broad outline indicates the scope of the lecture and laboratory courses:

(a) The physical and chemical properties of gases, including fundamental laws of gases, kinetic theory, liquefaction, dissociation, viscosity and flow of gases; nature and velocity of chemical reactions; chemical equilibrium; influence of moisture, surface and pressure in gas reactions; occlusion of gases, principles of thermochemistry.

The mechanism of combustion; ignition points; flames and explosions; combustion of carbon; carbon monoxide; carbon dioxide; cyanogen, hydrogen, and all hydrocarbons; thermal decomposition of hydrocarbons; action of steam on incandescent carbon.

(b) The technology of fuel, including the mechanical theory of heat; specific and latent heats; heat of combustion of solid and liquid fuels; calorimetry; principles of gas analysis and manipulation; preparation of pure gases; fractionation of gas mixtures; collection and storage of gas samples; solubility of gases in liquids.

Discussion of solid, gaseous and liquid fuels—coal, coke, lignite—natural gas, producer gas, coal gas, water gas, petroleum and other oil fuels.

(c) By-product coking processes. Description and theory of the various chambers and retorts used in the carbonization of coal.

(d) Details of manufacture and purification; methods of distributing, storing and measuring gas; high and low pressure distribution.

(e) Economics of gas manufacture and distribution, financing, cost, accounting, rate making.

It has been found by the Johns Hopkins University that it is decidedly advantageous for engineering students to delay specialization until the fourth year of the undergraduate course, and the engineering work is arranged accordingly. Opportunity is thus afforded for a thorough grounding in mathematics, physics and chemistry, and for a study along various broadening lines before the student begins to devote his time to any one special field. In the third undergraduate year each student takes courses in the elements of heat-power engineering, electrical engineering, and in the mechanics of structures.

The new course in gas manufacture and by-products is elected in the fourth year by those who desire to pursue that subject. Seventeen seniors and graduates are taking the work this year, the lectures being delivered by Capt. F. H. WAGNER, chief engineer of the Bartlett Hayward Company. Mr. Wagner is devoting the necessary time to this work because of his interest in seeing adequate facilities afforded at Johns Hopkins for instruction and research in this subject. It is hoped to erect a small coal-gas plant of one retort capacity, specially adapted for research work, in the laboratories.

It is the intention of the department of engineering to publish monographs covering the work done, copies to be distributed to those interested as soon as issued; besides this, the facilities of the laboratory will be available so far as possible for such special research work as may be of interest to the gas industry, full reports of results secured being published as soon as complete.

Unusual facilities are available in Baltimore and vicinity for studying the practical operation of by-product plants, as well as gas manufacturing plants, and the location is especially favorable for the experimental coal gas plant at Johns Hopkins University.

Cyaniding by Continuous Decantation at Two Nevada Silver Mills

(Editorial Correspondence)

Pittsburgh-Dolores Mill

In METALLURGICAL & CHEMICAL ENGINEERING for January, 1915, there appeared a brief outline of the proposed equipment and process to be used at the mill of the Pittsburgh-Dolores Mining Co., at Rockland, about twenty-eight miles south of Yerington, Nevada. This mill has now been in operation since June, 1915, and, by reason of the complete records kept, affords some interesting data on cyaniding by continuous counter-current decantation. It also provides an instance of the adaptation of an old plant to modern methods, for the original mill was designed for leaching only and has been converted to the use of an all-sliming process. The average tonnage treated based on actual operating time has been better than fifty tons per day.

The original roll-crushing equipment has been retained, although its deficiencies are recognized, the machines being of much lighter construction than is considered necessary in modern design. For fine grinding, a tube-mill has been added which runs in closed circuit with a Dorr classifier. The old leaching vats, 30 ft. by 5 ft., have been converted into Dorr thickeners, and three Dorr agitators, 22 ft. by 19 ft., have been added.

Crushing and Grinding

An average assay of the ore treated will show about 0.44 oz. gold and 3.4 oz. silver per ton. Moisture content will run from 4 to 5 per cent. The gangue is quartz and granodiorite, and parts of it are exceedingly hard. Coarse crushing is done in a Blake, 8 in. by 12 in., delivering a 1 to 1½ in. product to a wet trommel covered with ½-in. mesh wire screen. Cyanide solution is added at this point. The trommel products are further reduced by coarse and fine rolls, all being finally delivered to a second trommel covered with No. 13 ton-cap screen. Formerly a Bunker Hill screen was used for the final sizing, but the discharge for oversize was too small to handle a considerable quantity of talc which passed the crushers and it was displaced by the trommel. The oversize of the second trommel is returned to fine rolls and the undersize flows to the tubemill-classifier circuit. The elevator used in the crushing department has 8 in. by 14 in. buckets on a 16-in. belt and has a speed of 289 ft. per minute.

The tube-mill is 5 ft. by 18 ft. in size and is driven by a variable-speed motor which transmits power through gears and silent chain. Sillex was originally used for lining and the mill was started with a load of 6 tons of Danish pebbles. Owing to the expense for pebbles and the high cost of transportation, hard mine rock was then substituted as a grinding medium, but this caused unusually rapid wear of the lining and after sixty days running time it was worn out and had to be replaced. The Belmont ribbed hard-iron liner was then installed, and the use of mine rock continued for grinding.

Cost of Tube-Mill Liners

Owing to the situation of the mill in the mountains at a distance of thirty miles from the nearest railroad point, hauling costs \$12 per ton, which will explain the high cost of delivering material at the mill site. The sillex lining cost, delivered, \$450, and the labor cost of installing was \$75, making a total of \$525 for a lining that lasted sixty days. The Belmont liner, from

which a life of from fifteen to eighteen months is expected, based on other experience, cost \$1,230 delivered. Of this amount the railroad freight was \$257 and the wagon haul \$135. The cost of placing the lining was unusually high as the shell had to be drilled, this operation alone costing \$45. In the future the labor cost of relining should be about \$35, and this would give a total cost for the Belmont lining of \$1,265, or about two and one-half times the cost of sillex. If, however, the Belmont gives from seven to nine times the life of sillex, the former will be much cheaper in the end.

The hard ore used for grinding is sorted at the crusher, and about 3000 lb. is charged daily. The tube-mill is shut down temporarily, the man-hole cover removed and the ore run in through a chute from a storage bin.

The moisture content of tube-mill pulp is between 38 per cent and 40 per cent. The pulp flowing from the classifier will average about 75 per cent minus 200-mesh. Screen analyses are made dry, using Tyler standard screens, and each operation is continued until the oversize product has a constant weight. A few screen analyses are given herewith.

Mesh	SCREEN ANALYSES, CLASSIFIER OVERFLOW			
	Percentage			
+ 35	0.00	0.00	0.00	0.00
+ 65	0.18	0.25	0.10	0.24
+ 100	0.90	2.45	2.40	0.97
+ 150	10.48	13.55	13.40	11.15
+ 200	9.20	13.30	10.30	12.08
- 200	79.30	70.25	73.80	75.30

Equipment for Decantation

The old leaching vats converted into thickeners are rather shallow, but as the area is large and the ore settles readily no difficulty is experienced in discharging a thick slime. The vats were originally set on the same level, making it impossible to get gravity flow of solution through the decantation system. In order, therefore, to secure thorough mixing of the thickened slime and decanted solution passing to the various thickeners, mixing cones were first installed into which pulp and solution flowed and from which the mixture was elevated slightly to thickeners by air-lifts. Floats in the cones rigidly connected to the air line maintained a constant level of pulp. The scheme was tried for a time but finally the cones were discarded. At present the pulp is lifted by diaphragm pumps and the solution by air-lifts, and mixing takes place in the launders into which the two materials are discharged. The air-lifts for solution each consume from 3 to 5 cu. ft. of air per minute. The air consumption for each Dorr agitator is 9 cu. ft. per minute.

The decantation flow-sheets have been tried since operations commenced. The original scheme, shown in Fig. 2, placed all agitators in series between the



FIG. 1—PITTSBURGH DOLORES MILL

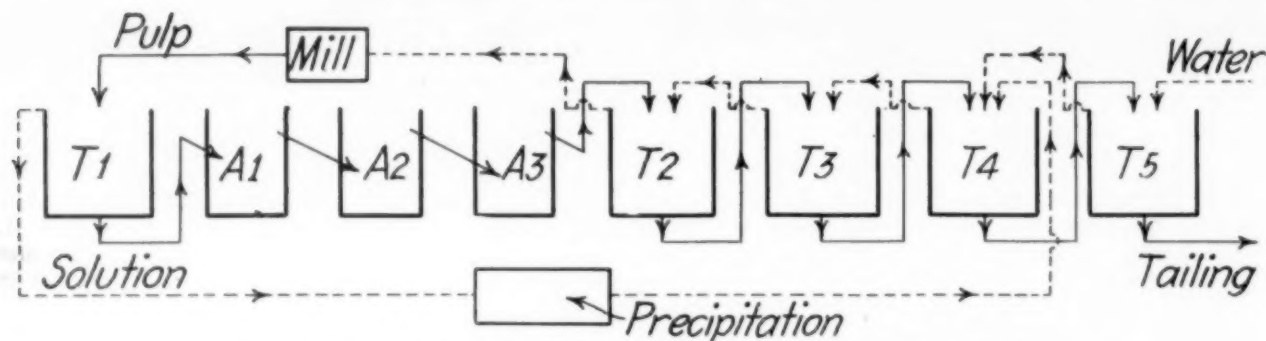


FIG. 2—ORIGINAL SCHEME OF DECANTATION—PITTSBURGH DOLORES MILL

first and second thickeners. This system was continued for about sixty days and complete data obtained on its operation. The scheme was then modified as shown in Fig. 3, introducing a decantation between the second and third agitators and thus giving the pulp a change of solution before final agitation. The effect was an increase in extraction of both gold and silver as shown by the reduction of undissolved loss from \$0.81 per ton in the first scheme to \$0.45 per ton in the second. The latter plan is now in operation.

Dissolved loss also was somewhat reduced, from 12.8 cents to 10.6 cents per ton, due probably to the fact that general operation was improved and further that the dissolution which probably occurred throughout the line of thickeners in the first instance was obviated by the change. Nevertheless reduction in dissolved loss probably was not as great as it would have been if an additional thickener had been added so that the customary four would follow agitation. The principle of changing solution between agitators has been quite well established in recent practice; but where this is done it is customary to add another thickener unless the ore is quite low grade. Otherwise three thickeners may not give sufficient opportunity for recovery of solution, and the dissolved loss will be unduly high. At the Rochester mill the extra thickener is in use, as shown in Fig. 5, and dissolved loss is lower than in the present instance. The use of four thickeners following agitation reduces solution values throughout that part of the system and consequently lowers dissolved loss by more than the 50 per cent which would be anticipated by the extra dilution. Thus in the present instance the dissolved loss of 10 cents per ton might be reduced to 4 or 3 cents by an additional thickener.

The essential data on the decantation process are given in Table I, where a comparison can be made between the results obtained by both methods.

The loss of dissolved metal per ton of dry slime is estimated by taking the average percentage moisture in the underflow of No. 5 thickener, multiplying by

the value of the solution contained and dividing by the per cent of solids. In this case the thickener underflow will average 50 per cent moisture, so that

TABLE I

Average results of continuous decantation by different flow-sheets, Figs. 2 and 3. Values figured at \$20 per oz. for gold and \$0.50 for silver; 24-hr. samples except as noted; pulp samples unwashed (filtered and drained) except as indicated. Figures arranged according to sequence of machines in flow-sheet, Fig. 3. Abbreviations: F. S. = flow-sheet; Tk. = thickener; Agt. = agitator; U. F. = underflow; O. F. = overflow.

No. of Machine and Source of Sample	PER CENT SOLIDS		INDICATED EXTRACTION AT DIFFERENT STAGES		ASSAY VALUES, PULPS OR SOLUTIONS	
	F. S. Fig. 2	F. S. Fig. 3	F. S. Fig. 2	F. S. Fig. 3	F. S. Fig. 2	F. S. Fig. 3
Mill head					\$10.65	\$9.12
PULPS—						
1 Tk feed	15.2	17.4	49.0	59.8	5.43	3.65
1 Tk U. F.	49.2	51.1	51.2	64.6	5.20	3.23
1 Agt.	30.4	36.1	72.5	73.2	2.93	2.44
2 Agt.	30.1	36.8	76.8	77.5	2.47	2.05
2 Tk U. F.	50.8	50.1	83.1	83.2	1.80	1.53
3 Agt.	29.4	32.3	78.2	87.4	2.32	1.15
3 Tk U. F.	49.7	49.4	87.5	89.9	1.33	0.92
4 Tk U. F.	53.0	49.3	89.8	92.0	1.09	0.73
5 Tk U. F., shift 1					0.88	0.51
5 Tk U. F., shift 2	52.2	50.4	91.6	94.2	0.94	0.53
5 Tk U. F., shift 3					0.87	0.53
5 Tk U. F., washed, 24-hr.			92.4	95.0	0.81	0.45
SOLUTIONS—						
1 Tk feed					2.25	2.21
1 Tk O. F.					2.14	2.04
1 Tk U. F.					3.01	3.03
1 Agt.					2.41	2.47
2 Agt.					2.48	2.56
2 Tk feed	17.0	15.7			1.40	1.02
2 Tk O. F.					1.28	1.03
2 Tk U. F.					1.29	1.13
3 Agt.					2.63	0.71
3 Tk feed	19.2	16.9				0.36
3 Tk O. F.					0.42	0.35
3 Tk U. F.					0.40	0.40
4 Tk feed	20.2	17.0				
4 Tk O. F.					0.14	0.14
4 Tk U. F.					0.24	0.18
5 Tk feed	35.4	32.7			0.19	0.10
5 Tk O. F.					0.13	0.09
5 Tk U. F., shift 1					0.17	0.10
5 Tk U. F., shift 2					0.13	0.10
5 Tk U. F., shift 3					0.14	0.10
5 Tk U. F., 24-hr.					0.14	0.10
Return solution					1.41	1.27
Zinc-box head					2.19	2.10
Zinc-box tailing					0.015	0.012
Dissolved loss per ton ore milled					0.128	0.106
Dissolved and undissolved loss per ton ore milled			91.2	93.8	0.938	0.561

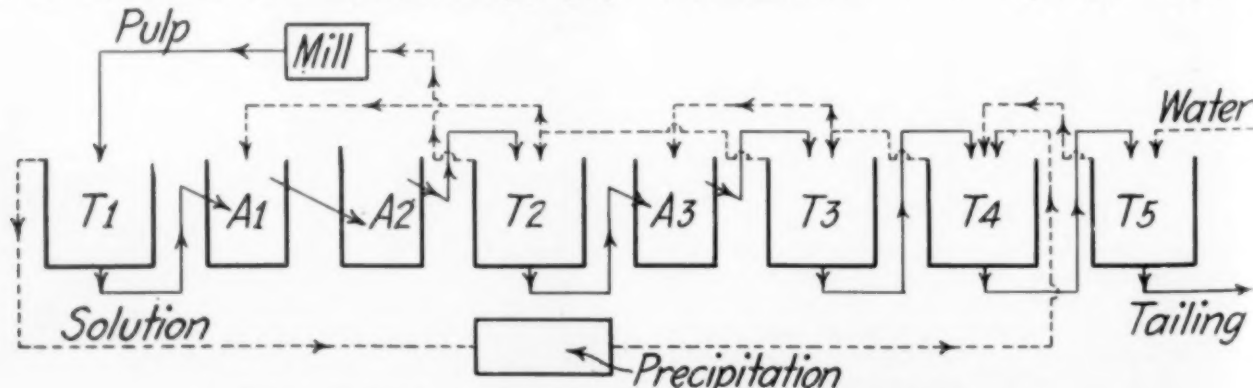


FIG. 3—MODIFIED SCHEME OF DECANTATION—PITTSBURGH DOLORES MILL

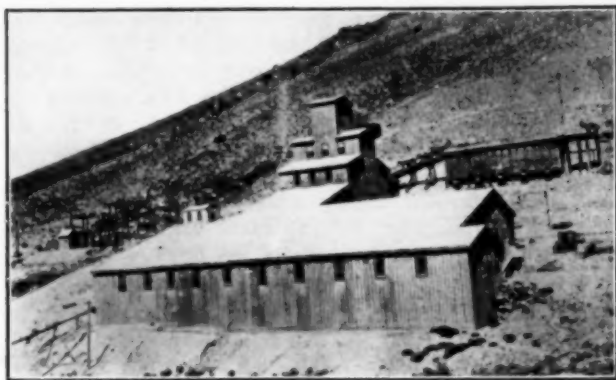


FIG. 4—ROCHESTER MILL

the value of the solution contained will be the dissolved loss per ton of dry slime.

A spring balance with a dial, such as is used in weighing parcel-post matter, is adapted to determining specific gravity of pulps. An arbitrary scale is prepared for the dial, indicating per cent solids, ratio of solution to solids, and specific gravity, so that these data can be read directly when a small bucket of slime is placed on the scale pan. If the bail of the bucket is made large enough to encircle the balance, the load can be suspended by looping the bail over the scale and its support, and thereby avoid spilling slime over the balance.

Pulp and solution samples from agitators and thickeners are taken hourly. The classifier overflow is sampled every half hour. The value of mill feed is determined by scoop sample of the dry crushed ore taken half-hourly at a plunger feeder.

Chemical Data

Aside from a high consumption of lime there is no unusual feature in the chemistry of the process. Some litharge is introduced at the tube-mill. Lime is added at the crusher and cyanide at No. 1 agitator. The strength of solution is 1.8 lb. KCN per ton, with 0.8 lb. CaO protective alkalinity. Consumption of chemicals is tabulated below in pounds per ton.

KCN (mechanical)	0.5
KCN (chemical)	0.1
CaO	14.0
Zn	0.8
PbO	0.4

The value of zinc-box head and tailing solutions is given in Table I. Under the scheme outlined in Fig. 2 about two tons of solution was precipitated per ton of ore; under the later scheme the ratio is about 3:1. Zinc-box precipitate is fluxed and melted in the usual manner. The flux consists of 1 part soda, 2.2 parts borax glass and 0.1 part silica. The resulting bullion has a fineness of 924, of which 817 is silver. Actual

extraction for the first six months of operation was 92 per cent.

Cost of Power and Milling

The cost of electric power is 1.07 cents per kw-hr. A feature of the decantation department is the small amount of power required, one 10-hp. driving all machines as noted in the accompanying table.

Machinery Driven	DISTRIBUTION OF MOTORS	Hp.
Crusher		15
2 rolls, elevator, 2 trommels, plunger feeder		50
Tube-mill (variable speed)		50
Dorr classifier		1
Compressor		10
Decantation system, 3 agitators, 5 thickeners, 5 diaphragm pumps, clarifier pump, return solution pump		10
Barren solution pump (2-in. Byron Jackson centrifugal, 28 ft. head)		2
		138

The original estimate for cost of milling was \$3 per ton. The actual cost for a recent month was \$2.69 per ton, covering labor, superintendence, supplies and power.

Rochester Mill

An outline of the equipment and process used at the mill of the Rochester Mines Co., Rochester, Nevada, was first given in this journal, November, 1914. A flow-sheet of the proposed system was also shown, being in effect the same as given in Fig. 2 for the Pittsburgh-Dolores mill, except that six thickeners were provided instead of five. The three agitators were arranged in series between thickeners 1 and 2, and barren solution was added to thickener No. 4. The use of six thickeners instead of five was determined after finding by calculation that a lower dissolved loss could be thus obtained than by using only five machines and a double precipitation circuit. A further reason for the additional thickener was to guard against an excessive dissolved loss in case very high-grade ore might be treated.

A modification of the original flow-sheet was made in this case as with the Pittsburgh-Dolores, by introducing a decantation between agitators 2 and 3, thereby getting the benefit of a change of solution. The scheme as finally adopted is shown in Fig. 5. In this case, however, there were already enough thickeners installed to provide the usual four after agitation, which probably explains the lower dissolved loss obtained at this mill.

Rochester ore is valued chiefly for silver and a small amount of gold. It contains none of the ordinary base metals, such as copper, lead or zinc. Over 90 per cent is silica, and there is but 0.3 per cent of sulphur. The silver is reported to be in combination with sulphur, and with antimony of which the ore carries about 0.25 per cent.

The mill was originally designed to treat on a custom basis the ore produced by lessees in the Rochester mine. For that reason five 60-ton bins were constructed

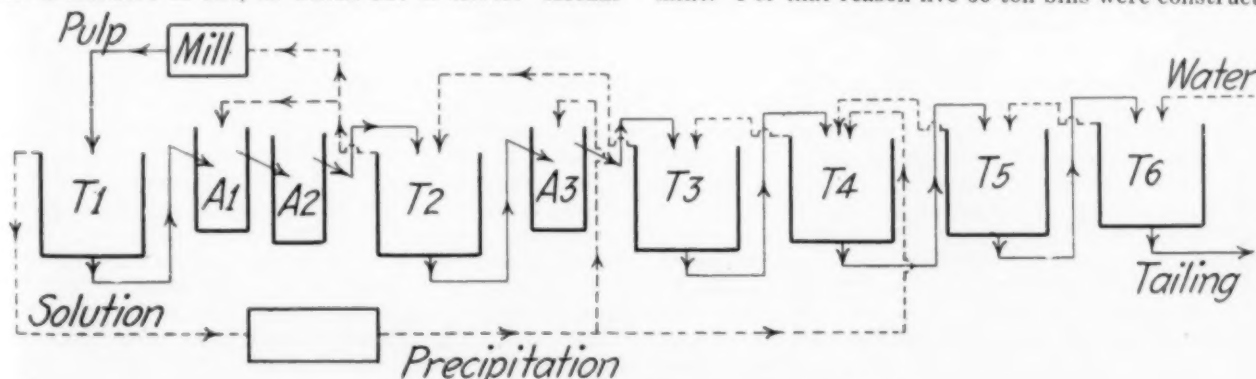


FIG. 5—SCHEME OF DECANTATION—ROCHESTER MILL

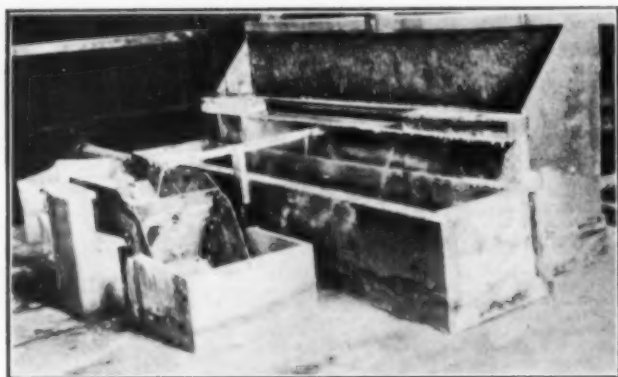


FIG. 6—TILTING-BOX SOLUTION METER—ROCHESTER MILL

and an elaborate sampling equipment installed. In the fall of 1915, however, the leasing system was discontinued and both mine and mill operated on company account.

With the completion of a spur from the Nevada Short Line, ore is now delivered to the mill bins by rail. From the bins it is trammed in $1\frac{1}{2}$ -ton cars to the sampling department where it is first weighed. The sampling equipment is of standard design and arrangement. There are three single Vezin samplers, each cutting one-tenth. The successive cuts are reduced in size and mixed before flowing to the next sampler, and the final cut gives one one-thousandth of the original lot.

The sampler reject is delivered to bins and thence to ten stamps. The latter weigh 1550 lb. and show a duty of twelve tons each per twenty-four hours, crushing through 6-mesh screen. Each battery of five stamps is driven by a 20-hp. back-geared motor, with special controller that makes it possible to start without previously having hung up the stamps. The ore is crushed in solution which is the overflow from No. 2 thickener, seven tons of solution being fed per ton of ore. The pulp flows to a Dorr duplex classifier placed between the two tube-mills which receive the coarse portion of the pulp and return the ground product again to the classifier. The classifier sand discharge is conveyed to the scoop feeders of the tube-mills by means of right and left-hand screws, and solution is added to give a moisture content of 38 per cent. Screen analyses of the classifier slime overflow will show about 90 per cent finer than 200-mesh. Komata linings and Danish pebbles are used in the tube-mills, both of which are driven by a single 100-hp. motor connected to the pinion shafts by silent chain drives with spring hubs and cut-off couplings.

Continuous Decantation of Slime

The scheme of decantation is shown in Fig. 5 which explains the process better than can be done by written description. The thickeners discharge a pulp containing from 44 per cent to 48 per cent moisture, except in the case of No. 6 which discharges a thicker pulp of about 42 per cent moisture. For agitation the pulp is diluted to 68 per cent moisture. Diaphragm pumps are used for the elevation of all pulps and the volume discharged is regulated by admitting air to the suction through pet cocks. In order to minimize the wear of diaphragms caused by rocking motion, the pumps are connected with overhead eccentric drives by means of 7-ft. rods which transmit motion to the diaphragms in an almost vertical direction.

Thickeners 2 to 6 inclusive are arranged on successively higher levels to permit the counter-flow of solution by gravity. The overflow of No. 1 is precipitated

and the barren solution is metered and returned to No. 4. The solution meter is of the tilting-box type shown in Fig. 6, connected with a counting device that registers each double throw of the box. The number of throws multiplied by a factor derived from the ratio of the full weir to the small launder leading to the tilting box gives the solution tonnage. The precipitation ratio is six tons of solution per ton of ore treated, being much higher than that for the Pittsburgh-Dolores mill on account of the higher grade of the ore. Water is introduced in the final thickener in amount necessary to counterbalance the loss of solution in the discharged tailing.

Prior to precipitation the solution is clarified in vacuum leaves, and at the zinc boxes a small amount of lead acetate solution is added. These precautions render precipitation highly efficient. As is customary with silver ores, the precipitate is not given an acid treatment before melting. It is dried, weighed, fluxed with soda, borax and fluorspar and melted in a Case oil-burning tilting crucible furnace. The resulting bullion has a fineness of 850 to 900 in silver and 5 to 6 in gold.

Small Loss of Dissolved Metal

Of the total silver dissolved, about 35 per cent goes into solution in the crushing and grinding apparatus, 55 per cent in the first two agitators and 10 per cent in the third. The strength of cyanide solution is kept up to 4 lb. KCN per ton by additions at No. 1 agitator. This solution is much stronger than that used at Pittsburgh-Dolores, and the mechanical loss also is higher, being about 1 lb. per ton. The loss of dissolved metal, however, is considerably lower, being reported by the management to be from 2 cents to 3 cents per ton. Lime consumption is high, varying with different lots of ore, but averaging 13 to 14 lb. per ton. Protective alkalinity is carried at $2\frac{1}{2}$ lb. CaO per ton. Lead acetate is added at No. 1 agitator and at No. 6 thickener.

The daily control of operations covers assays of pulps and solutions as previously shown for the Pittsburgh-Dolores mill. The value of mill feed is accurately determined by the automatic sample.

Comparison of Flow-Sheets

A comparison of the flow-sheets shown in Figs. 3 and 5 will show some variations in the counter-flow of solution. In one particular they are alike, viz., in dividing the agitation, giving part before and after an intermediate decantation. In the counterflow of solution the main differences are found in the return of barren solution to the system and in the way in which the overflows are diverted. In Fig. 3 all barren solution is returned to No. 4 thickener; in Fig. 5 there is a division of this solution, part going to No. 4 thickener and part to No. 3 agitator. The latter may be done in case it is found that dissolution is stimulated by the addition of fresh barren solution; otherwise the scheme in Fig. 3 may be followed, where part of No. 4 overflow is sent to No. 3 agitator. Again, in Fig. 3 the overflow from No. 3 thickener is used partly in the first agitator, while in Fig. 5 the overflow from No. 2 thickener is thus used.

The theoretical merits of different schemes can be computed from such known or determinable data as tonnage of ore, thickness of discharged slime, value dissolved per ton of ore, precipitation ratio, density of pulps in agitation, strength of cyanide solution, etc. The critical points are the loss of dissolved metal and mechanical loss of cyanide, and a flow-sheet should be adopted which shows the lowest combined value for these losses. The dissolved loss will be affected by the grade of the ore and the number of thickeners in use, and can be regulated in part by the amount of solution

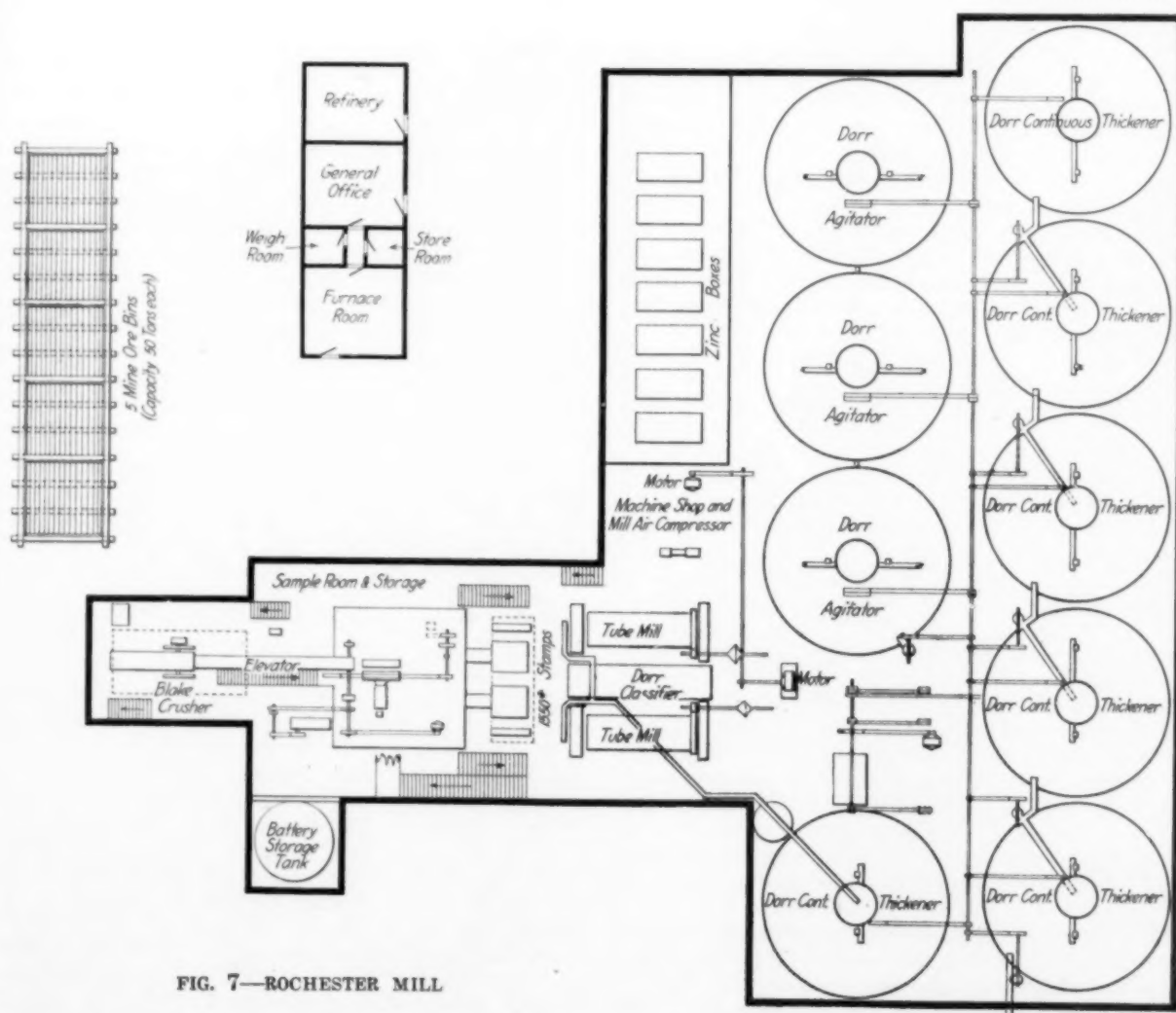
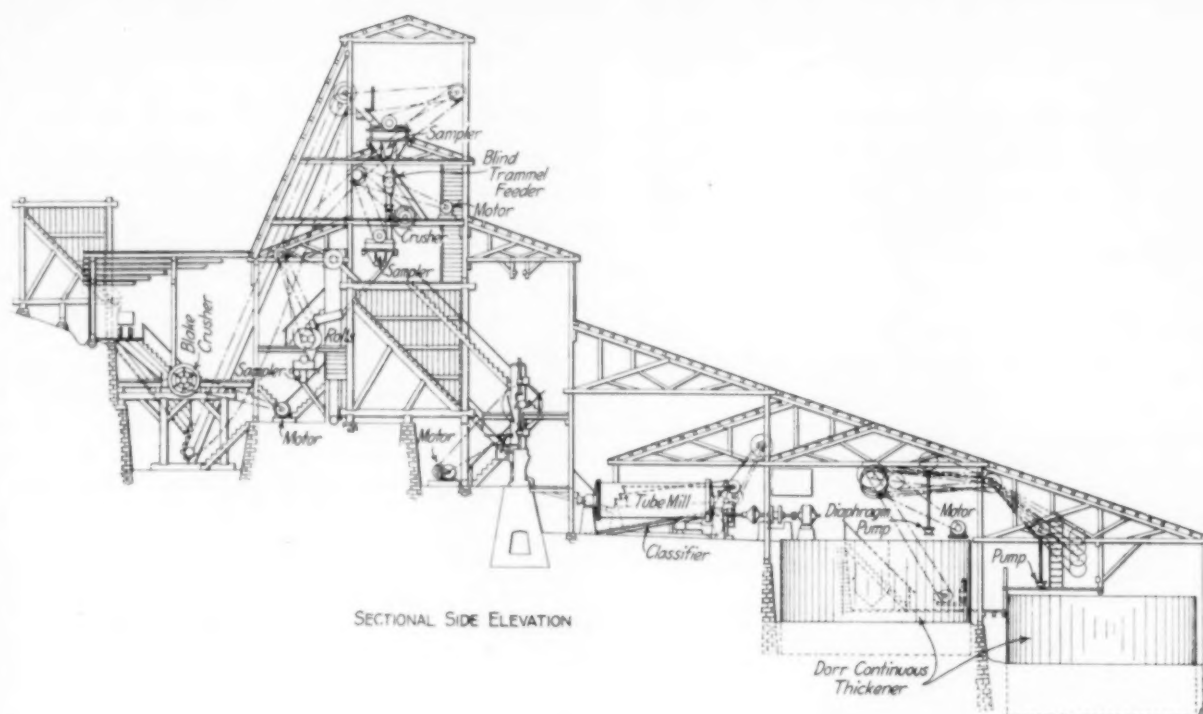


FIG. 7—ROCHESTER MILL

precipitated per ton of ore treated. Local conditions may determine the value of these variations, and a variety of counter-flows can be arranged to meet special needs. The settling area required per ton of solids and the density to which pulp can be thickened are important considerations.

For the information and data given on these two interesting plants we are indebted to Mr. E. J. Schrader, manager, and C. R. Olson, mill superintendent of the Pittsburgh-Dolores Mining Co.; and Mr. C. W. Poole, manager, J. C. Rasmussen, foreman, and W. C. Em-minger, chemist, of the Rochester Mines Co.

Application and Earning Power of Chemistry in the Coal Mining Industry*

BY EDWIN M. CHANCE

During the last decade many conditions have been encountered that have materially increased the cost of the production of coal. As in most cases it has not been practicable to increase the selling price of such coal sufficiently to insure the necessary margin of profit, the mine management has been forced to avail itself of what

sales departments had felt convinced of the inferiority of this type of fuel and when complaints had been registered these complaints were given ready credence. Upon convincing the sales department of the quality of this type of fuel, but little difficulty was experienced in securing a ready market for it and it was even found possible to secure premiums for certain of these dull coals.

It is readily understandable that the only available means whereby a true appreciation of the quality of a fuel can be arrived at is by its chemical analysis or by a service test. The cost and unreliability of service tests have led to their general abandonment, hence the chemical examination of a fuel has been found to be perhaps the most ready and practicable method for determining its real position in the scale of usable fuels.

Now when we consider that in the past hundreds of thousands of tons of dull and unpromising looking coal have been gobbled at a positive cost to the coal producer, with the ever present danger of gob fires, that many other hundreds of thousands of tons of this material have been sent to the rock bank as refuse, and that because of the similarity of the specific gravities of the dull and bright coals, the difficulties and inefficiencies

TABLE I—AVERAGE COAL ANALYSES

Size	Test Number	Color of Ash	Moisture, Per Cent	Volatile Matter, Per Cent	Fixed Carbon, Per Cent	Ash, Per Cent	Sulphur Per Cent	Heating Value per Pound Coal as Received, B.T.U.	Heating Value per Pound Dry Coal in B.T.U.
Dull coal	C-502	Red	2.98	6.39	82.24	8.39	0.67	13,110	13,510
Bright coal	C-503	Red	3.70	5.67	81.16	9.47	0.71	12,890	13,380

might be termed unusual means that costs might be held at as low a figure as possible. The so-called efficiency engineer has been called upon, costly power plants have been built and machinery has been installed to replace manual labor wherever possible.

Another aid used recently to secure economies through the more intelligent production of coal, is the chemist. As the coal industry, barring the production of by-product coke, does not at once give evidence of its need of the services of the chemist, the writer will endeavor to point out a few of the services that this branch of the staff has been able to render.

COAL ANALYSIS.

The preparation of coal in the past has been carried on entirely upon an empirical basis, that is, the criterion adopted has been an ocular inspection. Unfortunately, the appearance of a coal and especially of an anthracite, has but little relation to its fuel value, and as long as coal is purchased for the heat that can be obtained from it by its combustion, the quantity of such heat that is purchased must be one of the principal desiderata in selecting or preparing a coal. Were coals purchased for use as bric-a-brac or for exhibition in museums it might be both wise and just to purchase them upon their appearance.

After 4 or 5 years of investigation the fact has been established that coals of very inferior appearance, and I now have special reference to anthracite, might and often did possess heating and burning properties superior to those possessed by bright coals which in the past had commanded considerable and uniform premiums in the market. This being the case the question arose as to whether the trade could be persuaded of this fact.

While at first some difficulty was experienced in establishing the quality of such dull coals, still it was found that the real obstacle to the sale of these materials in the past had been the fact that the coal producers' own

of coal preparation have been enormously increased by the attempted removal of this material, it will be seen how enormously profitable the utilization of this excellent fuel has been.

In order to give an adequate idea of the relative worth of the dull and bright material from the same veins, I will give in Table I the following average analyses:

These analyses are in both cases the average of a number of analyses of characteristic material of both types, and are in no sense selected. In the past this dull material, test No. C-502, has been condemned as bone. Thus by a systematic chemical investigation of the various steps in the preparation of coal undiscovered inefficiencies are revealed and their correction is made possible.

BOILER WATER.

In the efficient operation of boiler plants it is necessary to secure as soft and non-corrosive a boiler water as possible. While the most desirable method is to secure a supply of water that is naturally soft, still in the mining industry it is frequently necessary to use water that is both incrusting and corrosive. To meet these conditions a host of so-called boiler compounds has been foisted upon the unsuspecting mine manager. While certain of these compounds are worthless or of little value, others have considerable merit in special cases. Unfortunately, however, their use is indiscriminately recommended by the vendor, and a boiler compound that might prove efficient with waters of a certain type will prove of little value under different conditions. Moreover, the cost of these compounds is out of all proportion to their merit and a grave and positive risk is run of doing the boilers infinite damage by the indiscriminate use of such nostrums. I recall at this moment the case of one new boiler house equipment of several thousand horsepower capacity that was so damaged by 3 months' use of a highly recommended water softener, even though the water in this case was not very hard, that it required over a year and a half of patient and costly effort to put the plant back in a

*A paper to be presented at the Arizona meeting of the American Institute of Mining Engineers (September, 1916).

condition having the semblance of efficiency. Now a competent chemist can readily recommend a treatment for such boiler feed waters that will meet the requirements of the particular case in question both cheaply and efficiently.

By reason of inadequate storage facilities at many mines, a prolonged drought will occasionally require the use of mine water as boiler feed. The writer recalls one occasion when a large number of collieries of one company were operated with such feed water, containing in many cases as much as 10,000 parts per million of free sulphuric acid and 35,000 to 40,000 parts per million total acidity. These plants were operated successfully over a period of months with such feed water, though of course many difficulties arose and much care was required, while the surrounding coal-mining companies, not possessing expert chemical assistance, were in many cases required to cease operation.

LUBRICATION.

The subject of lubrication is one that has in the past been favored by the so-called efficiency expert. It is, therefore, with a sense of some diffidence that the writer approaches this subject. As conditions governing colliery lubrication are so very different from those governing the lubrication of the mill or industrial plant, it has been found that the lubrication secured by the use of lubricants recommended by the vendor has in the past been unsatisfactory and somewhat costly. Some years ago the writer conducted numerous field and laboratory tests in order to establish just which lubricants would best meet coal mine conditions. After these points had been well established an effort was made to go into the open market and, by specification, purchase the material desired.

While this plan was successful, still it was found that almost continual testing of the material supplied was required, as the bidders purchased their materials in the open market and hence there was little or no uniformity of supply. Those bidders not purchasing oils in this way were, in many cases, refiners handling such a diversity of crudes that practically the same complaints arose. It was found that the independent refiners of Pennsylvania petroleum produced the lubricants required, and since the materials were produced by them and their range of production was rather limited, little difficulty was encountered in securing uniform products from them. Moreover, by concentrating the purchases for a number of coal producers upon one refinery, it has been possible to secure most advantageous prices while at the same time the quality of materials supplied is directed by the purchaser and not by the vendor.

In other words, the oil to meet any special condition is purchased from the refiner without consulting him as to its use. Hence there is little or no probability of his attempting to substitute a material that he may consider almost as suitable, as he has no knowledge of the use to which the material in question is to be put. It is an axiom that given a maximum price that a purchaser will pay, the average vendor will endeavor to supply the material that costs him the least but that will meet the condition in question. In purchasing lubricants as indicated above this condition does not arise, as the oil for the purpose in question is selected without considering its price, and further, since the vendor is not consulted in the matter, the best oil that can possibly be obtained for the particular purpose is secured.

It may seem that the cost of such a procedure would be prohibitive, and this would be the case were these materials purchased at the scale of prices that usually obtains. By means of the co-operation mentioned above,

however, prices have been secured that are so advantageous that the highest grade of product that it is possible to secure, irrespective of price, is generally purchased at a lower price than the product of mediocre quality that was formerly used. In this way the actual first cost of lubrication has been reduced from 30 to 50 per cent, while the actual efficiency, though less readily determinable, of the lubrication secured has been greatly increased.

MINE FIRES.

The chemist has been found to be almost indispensable where a mine fire is being extinguished by cutting off its air supply, for the chemical analysis of the air from the fire zone makes it possible to form an intelligent opinion of the progress of the extinction and the airtightness of the dams or fire walls built to control the fire.

Many more instances than those briefly touched upon might be quoted and those that have been quoted might be developed in greater detail. Such a dissertation, however, would be burdensome and would fall without the purpose of these notes.

Wilkes Barre, Pa.

The Electrolytic Determination of Copper in Copper-Manganese

BY EMIL D. KOEPPING

When determining copper by electrolysis in the presence of large amounts of manganese, the simultaneous deposition of copper at the cathode and manganese at the anode affords at best uncertain results. Too, the determination of manganese by electrolysis lacks interest. For these reasons the work described in this paper deals wholly with methods of depositing copper which also prevent the deposition of manganese.

So far as I have been able to find out only two methods of accomplishing this have been advanced. Classen¹ recommends the use of a large excess of nitric acid in the electrolyte, while E. F. Smith² mentions the use of a phosphoric acid solution. The objection to Classen's method is the ever-present liability of losing some of the copper by solution in the strong nitric acid during removal of the electrode. The method given in the old edition of Smith results in bad-colored deposits, as was expected.

A hint given by McCay³ in his paper on the separation of copper and lead from antimony and tin was developed and, with slight modifications, yielded good results.

For convenience the methods of accomplishing the purpose have been divided into two general classes:

I. Soluble anodes.

II. Special electrolytes.

In all experiments where stationary electrodes were used the current was 3 amp. at 3 volts, and where the rotating electrode was employed the current used was 9 amp. at 3 volts. The volume of electrolyte was in all cases 125 c.c. The results recorded under each experiment are typical of those obtained.

I. Soluble Anodes

(a) IRON ANODE

It is well known that copper can be determined in the presence of large amounts of iron by several means. A simple way is to limit the quantity of nitric acid to 1 c.c. in 125 c.c. of electrolyte. The solution of the salts (sulphates or nitrates) was first neutralized with am-

¹Classen-Hall, Quant. Anal. by Electrolysis (1913), p. 281.

²E. F. Smith, Electro-Chemical Analysis (1890), p. 92.

³L. W. McCay, J. Amer. Chem. Soc., 36, 11, p. 2375.

monia and then acidified with 1 c.c. of sulphuric acid and 1 c.c. of nitric acid.

1. Cu present	Cu found	Error	Mn present
0.3975	0.3963	-0.0012	0.0978

Stationary Pt gauze cathode.

Stationary, pure iron, spiral anode.

2. Cu present	Cu found	Error	Mn present
0.3500	0.3484	-0.0016	0.1500

Rotating copper gauze cathode.

Stationary, lattice form, piano-wire anode.

3. Cu present	Cu found	Error	Mn present
0.3500	0.3491	-0.0009	0.1500

Rotating copper gauze cathode.

Stationary, lattice form, piano-wire anode.

(b) NICKEL ANODE*

The solution to be electrolyzed (sulphates or nitrates) was neutralized with ammonia and then acidified with 2 c.c. of nitric acid and 1 c.c. of sulphuric acid and diluted to 125 c.c. in each case.

1. Cu present	Cu found	Error	Mn present
0.3860	0.3853	-0.0007	0.1119

Stationary Pt gauze cathode.

Stationary heavy nickel-wire anode.

2. Cu present	Cu found	Error	Mn present
0.3500	0.3494	-0.0006	0.1500

Rotating copper gauze cathode.

Stationary heavy nickel-wire anode.

3. Cu present	Cu found	Error	Mn present
0.3500	0.3494	-0.0006	0.1500

Rotating copper gauze cathode.

Stationary heavy nickel-wire anode.

4. Cu present	Cu found	Error	Mn present
0.3860	0.3855	-0.0005	0.1119

Stationary copper gauze cathode.

Rotating nickel-paddle anode.

(c) ZINC ANODE

The solution for electrolysis was prepared in the same way as were those under (b).

1. Cu present	Cu found	Error	Mn present
0.3500	0.3412	-0.0088	0.1500

Rotating copper gauze cathode.

Stationary C.P. zinc-rod anode.

Some copper separated on the anode in a loosely adherent form. Most of this redissolved, but some did not. Zinc sulphate formed and adhered to the anode. A pure nitric acid electrolyte might overcome these objections but was not tried.

(d) ALUMINIUM ANODE

The solution was prepared in the same manner as under (b).

1. Cu present	Cu found	Error	Mn present
0.3500	0.3484	-0.0016	0.1500

Rotating copper gauze cathode.

Pure aluminium-wire anode.

(e) CADMIUM ANODE

Only a qualitative experiment was made for the cadmium seemed to be open to the same objections as the zinc anode.

II. Special Electrolytes

(a) Electrolyte containing 25 c.c. conc. nitric acid.

1. Cu present	Cu found	Error	Mn present
0.3525	0.3520	-0.0005	0.1500

Rotating copper gauze cathode.

Stationary lattice form Pt anode.

(b) Electrolyte containing sulphuric, nitric and hydrofluoric acids.

The solution of the metals after neutralizing with ammonia was acidified with 1 c.c. of sulphuric acid, 2 c.c. of nitric acid, and 1 to 2 c.c. of 48 per cent hydrofluoric acid.

1. Cu present	Cu found	Error	Mn present
0.3525	0.3522	-0.0003	0.1500

Stationary platinum gauze cathode.

Stationary Pt spiral anode.

2. Cu present	Cu found	Error	Mn present
0.3525	0.3521	-0.0004	0.1500

Stationary Pt gauze cathode.

Stationary Pt spiral anode.

3. Cu present	Cu found	Error	Mn present
0.3860	0.3857	-0.0003	0.1119

Stationary Pt gauze cathode.

Stationary Pt spiral anode.

(c) Electrolyte containing sulphuric, nitric and phosphoric acids.

The solution of the metals was neutralized with ammonia and then acidified with 1 c.c. of sulphuric, 2 c.c. of nitric and 5 c.c. of phosphoric acid.

1. Cu present	Cu found	Error	Mn present
0.3860	0.3856	-0.0004	0.1119

Stationary Pt gauze cathode.

Stationary Pt spiral anode.

2. Cu present	Cu found	Error	Mn present
0.3975	0.3973	-0.0002	0.0978

Stationary Pt gauze cathode.

Stationary Pt spiral anode.

3. Cu present	Cu found	Error	Mn present
0.3500	0.3495	-0.0005	0.1500

Stationary Pt gauze cathode.

Stationary Pt spiral anode.

CONCLUSIONS

The results obtained with the nickel anode are perhaps sufficiently accurate for rapid control work. The results obtained with the hydrofluoric acid electrolyte and with the phosphoric acid electrolyte, which also contains free nitric and sulphuric acids, leave little to be desired. Glass beakers can be used with the hydrofluoric acid electrolyte without difficulty.

Lockport, N. Y.

Russian Chemical Industries

According to information received from Russia the *Chemical Trade Journal* (London) says the Industrial Mobilization Committee of Moscow has decided that there is no occasion to erect new works for the production of sulphuric acid, but that the output of the existing works should be increased, particularly in the case of oleum and oil of vitriol. The committee expresses the opinion that with the object of avoiding an exaggerated rise in the price of and speculation in sulphuric acid, after the requirements of the army have been satisfied, the whole of the available quantity then remaining should be placed at the disposal of the committee for distribution among private consumers at a uniform price.

The discovery of deposits of saltpetre in the Altai was reported a few months ago. An expedition is now being formed to set out to investigate the deposits. It is also proposed to make further researches and new borings for saltpetre near the Iessentouki station.

In the case of the production of soap the Committee of the Union of Zemstvos of the Southwest of Russia has rented the Seidel Works near Kieff for the manufacture of soap. It is possible to produce 5000 poods per month, of which the fatty materials would represent about 60 per cent (1 pood = 36 pounds).

The question of the deposits of sulphur in the district of Kertch is to form the subject of a report by the authorities of Simferopol to the president of the Government Committee on Industrial Mobilization, with the

*When using commercial "pure" nickel it is necessary to determine the copper contents and average consumption of nickel for the time and current density being used and to subtract the "copper value" of this amount of nickel from the weight of deposited copper.

object of the adoption of measures for working the deposits.

The prices of chemical products at Petrograd are reported to have again increased all round, and no transactions are taking place in certain products, the quotations for which are purely nominal. This is particularly the case with borax in crystals, arsenic in powder and lump, ammonia salts, sulphur, etc.

Burdening the Blast Furnace

BY J. E. JOHNSON, JR.

This is the technical name for regulating the different materials used in the charge and the proportions of each to bring about, first, the successful operation of the furnace; second, the production of the kind of iron desired.

The quality of the iron depends principally upon its content of six elements—silicon, sulphur, phosphorus, manganese, carbon and oxygen, these being given approximately in the order of their importance as effecting the general character of the product. Some of these elements come from one portion of the charge and some from others.

We must, therefore, consider the burdening of the furnace from two points of view, first, that of the raw materials charged, which determines the quantities of foreign substances entering the furnace; second, from the point of view of the iron to be made. The content of the iron in the ingredients mentioned varies very widely, according to the purpose for which it is intended. The different varieties of iron and their contents in the different metalloids will be discussed later in an article on "Product." We will, therefore, consider here only the methods of controlling the quantities of the different elements mentioned above which enter the iron.

Silicon Control

To produce the desired silicon percentages we have two principal means which may be used singly or in combination. These factors are in the order of their importance: First, temperature, and, second, slag composition.

Since the temperature of reduction of silicon is far higher than that of iron and since the affinity of the latter for silicon diminishes as the percentage of the silicon in the iron increases, the temperature necessary to secure increasing percentages of silicon rises steadily as the silicon rises above 1 per cent. (Below that point in coke practice other factors come in.) Therefore, as we desire to raise the silicon we must first of all generate more hearth heat; so unless we can increase the blast temperature we must use more fuel.

Second, we must control the silicon entering the iron to a very large extent by the character of the slag which we use. With a given temperature of slag the limier one will have the stronger affinity for the silica as such, and will, therefore, carry off a larger percentage of it in its unreduced condition, while if the temperature remains the same, as the lime in the slag is lowered the equilibrium between the iron and the slag is shifted toward the iron and more silica is reduced to silicon and passes into the iron.

It will be noted that pains have been taken to specify that the temperature be the same, and this is a very important stipulation because generally in coke practice the temperature of the slag rises with its content of lime, and, as I have before explained, it is the temperature of the slag which controls that of the iron, the slag being less fusible and acting as a retardant in the bosh, down through which the iron must pass on its way into the hearth. Therefore, the more infusible the

slag the higher the temperature of the iron, the stronger the reducing action of the coke on the silica, and the higher must be the silicon in the iron to reach equilibrium with the silica in the slag.

This action is so important that it is sometimes impossible to obtain the required amount of silicon in the iron without increasing the lime far beyond what is necessary for desulphurization in order to raise the slag and through it the iron to the required temperature. In other words, there are actual conditions under which increasing the lime *increases* the silicon in the iron, the temperature effect of the increase more than offsetting its chemical effect.

In the article on slag it was shown that alumina had a decided effect in raising the free-running temperature of the slag without causing any increase in the basicity of the slag. The addition of alumina, therefore, gives us the higher iron temperature desired without increasing the affinity of the slag for the silica and so withdrawing it from the iron. For this reason the possibility of the use of alumina in considerable quantities in foundry iron slags was suggested in the paper quoted therein, and I have since come across statements in literature on the subject and from furnace operators confirming the correctness of this conclusion. My own experience does not cover the point exactly. The model showing the melting temperatures of lime, silica and alumina mixtures shows that the curve representing the effect of alumina alone is by no means a smooth and regular one, and it is, therefore, to be expected that a given increase of alumina would have different effects in different portions of its range.

The Effect of Magnesia in the Slag

The fundamental slag is composed of silica, lime, alumina. The effect of an addition of magnesia follows the universal law that an addition to the number of bases lowers the fusion point of the whole. Magnesia is probably not more active, weight for weight, than lime, although on the basis of its atomic weight, or the molecular weight of its oxide, 40 against 56 for lime, it should be 1.4 times more active. It does, however, have the effect of thinning the slag very materially and this is of enormous value, particularly in the manufacture of low-silicon irons; in exactly the opposite way from that in which alumina is probably of value for the manufacture of high-silicon ones. It lowers the melting point without altering the basicity of the slag.

This is of particular importance in the manufacture of iron for the basic process, whether Bessemer or open hearth, in both of which silicon is objectionable because the silica resulting from its oxidation attacks the basic (lime or magnesia) lining of the vessel and rapidly eats it away.

In coke practice it is not difficult to keep the silicon in the iron down to about 1 per cent, simply by adding more burden and thus keeping the hearth temperature too low to permit more silicon than this to enter the iron, while the furnace still remains hot enough to obtain good desulphurization. Below this point, however, difficulties begin to appear because if the hearth temperature be kept down for the production of a lower silicon than this with the same kind of slag, the point having been reached at which the slag is approximately saturated with that element for the given conditions, the surplus begins to pass into the iron. We must, therefore, take some step to prevent this action. The obvious one is to increase the lime in the slag, but this has the effect of increasing its temperature simultaneously, which in turn requires additional fuel, and these two factors are the very ones required to raise the

silicon, whereas what we are trying to do is to lower it.

We must, therefore, find some method of increasing the basicity of the slag without increasing its temperature. This method, and practically the only one available for the purpose in ordinary practice, is to substitute magnesia for a portion of the lime. The famous experiments of the Swedish investigator, Akerman, while not directly applicable because he determined the softening point rather than the free-running temperature of the slags, indicated that the most fusible slag was to be found with about two parts of lime to one of magnesia, and while the data of furnace operation are seldom or never accurate enough to determine points like this with mathematical accuracy, such data as we have seems to bear out the correctness of this ratio for practice.

Control of Sulphur

This is the element which indirectly produces most of the difficulties in the operation of the blast furnace. Charcoal furnaces have the vast advantage of a fuel almost free from sulphur, and unless this element be introduced with the ore or flux (which should never be done in charcoal practice because it vitiates the advantage of the fuel) there is so little of the element present that even a relatively very acid slag takes out nearly all of it.

In coke practice the conditions are very different; there is always sulphur in considerable amount in the fuel. There are exceptional cokes containing 0.5 per cent or even less of this element, and considerable quantities containing from 0.5 to 1 per cent, but a large and increasing percentage of all the coke now used in the district served by Lake ores runs from 1 per cent to 1.4 per cent in sulphur, and in some other districts the sulphur may even go higher than this. In a rough way about 1 lb. of coke is required to make a pound of iron, and as the sulphur limit on practically all iron is under 0.06 per cent it is evident that at least fifteen-sixteenths of the total sulphur charge must be removed by the slag, generally more.

There are two routes by which the sulphur can leave the furnace without contaminating the iron. It can be volatilized and passed off with the top gases or it can be fixed and carried out by the slag. In general it probably follows both routes to some extent, but the greater portion always goes out in the slag.

Very little is known as to the amount of sulphur which can be driven off with the top gases. The subject has been very generally neglected, but Mr. James Bell, superintendent of furnaces at the Algoma Steel Works, having had to use an ore containing a considerable percentage of sulphur, has made some very interesting investigations and has found that as much as 35 per cent of the total sulphur may be volatilized and pass off with the gas, and so not require to pass through the hearth at all.

The principal condition for bringing about this end he has found to be that the slag shall be as acid as the conditions permit; as the slag becomes more basic more and more of the sulphur is fixed by it and prevented from volatilizing. From the point of fuel economy there is absolutely no doubt of the desirability of keeping the sulphur out of the hearth altogether rather than permitting it to enter and then eliminating it.

That the sulphur has no ill effect on the gas for use under boilers and in stoves can be stated positively, for the total amount present in that gas with the maximum degree of volatilization mentioned (35 per cent) is but a small fraction of that in the products of combustion of many coals in successful use under boilers. The presence of sulphur does not seem to injure the gas

even for gas engines, as the plant mentioned is equipped with these and no trouble from corrosion has arisen after several years' use.

For keeping out of the iron the sulphur which reaches the hearth we have available, as described in the article on chemical principles of the blast furnace, five possible methods: increasing the lime content of the slag, increasing its volume, increasing its temperature, increasing its fluidity, and increasing its manganese content above those required in the absence of sulphur. Some of these methods assist one another, while others are in direct conflict. The best result must be obtained by a proper balance among all, for the determination of which there is no mathematical equation; in this, as in other departments of furnace operation, there is no substitute for horse sense.

By increasing the lime, leaving out for the present all question of temperature, we obviously provide additional free base, and we can see that if the slag was in a comparative state of equilibrium before, both the bases and the silica being reasonably well satisfied, it is obvious that this additional base will hunt some other acid in order to satisfy itself, and the only one available is the sulphur in the coke. Of course, as a matter of fact, the addition of lime simply alters the ratio of the lime to the silica, and so modifies the slag, but this alters the equilibrium, and if we conceive that the amounts of sulphur passing into the iron and into the slag were in equilibrium before, it is obvious that this equilibrium has shifted toward the slag, and that more thereafter must pass into the latter.

Increasing the volume of the slag diminishes the concentration of the sulphur in it, and similarly alters the equilibrium of the slag in regard to this element. Or, to put the matter in a still simpler way, if a given amount of slag absorbs and carries off a given amount of sulphur under certain conditions, then an increased volume of slag will dispose of a proportionally increased quantity of sulphur under the same conditions. Of course, the effect of the addition of lime is to increase the slag volume and we obtain the benefit of a slight increase in volume whenever we increase the lime, but this is generally less than 5 per cent. Where an excessive amount of sulphur must be eliminated, it is sometimes necessary deliberately to add to the burden slag-forming materials, in general silica, and the necessary lime to flux them, so as to make a substantial increase in slag volume.

Here again we have to meet a condition for which theory indicates qualitatively but not quantitatively the method to be followed. By adding lime we increase the free base, increase the slag volume, and increase the fusion temperature of the slag, all of which have a very strongly desulphurizing effect. But the more limey slag brings more sulphur into the hearth to be eliminated, while the effect of increasing the temperature of the slag is to increase the critical temperature of the furnace and thereby materially increase its fuel consumption. If, on the other hand, we add to the burden silica and sufficient lime only to keep the ratio of the two the same as before we must make in general a much larger addition to the slag volume to accomplish the desired desulphurization, but we do not increase the critical temperature; we do, however, increase the requirements for hearth heat to melt the additional slag. Both of these methods of increasing the removal of sulphur, therefore, have the result of increasing the fuel consumption.

I do not believe it is possible to figure out in advance which one of these is the most economical, or whether the combination of the two is more economical than either. The latter is probably true, but the final de-

cision can be correctly made only on the basis of experiment on the furnace itself.

We have seen that the first three methods of increasing desulphurization work together. That is, that an addition of lime meets all three conditions to some extent. But we have the fourth method, that of increasing the fluidity of the slag; and this is extremely important. I have already described how certain slags so limey as to "slack" when cold, if the hose was turned on them, fail utterly to give satisfactory desulphurization, partly because they raise the critical temperature so high that but little hearth heat is left above it, but very largely also because the slags are too stiff and pasty to mingle intimately with the coke, and so catch the sulphur as it is evolved by the combustion of the latter.

It is evident then that this need for fluidity sets a definite limit which we may not pass in adding lime for the utilization of our first three methods. On the other hand, we have no commercial method whereby we can increase the fluidity of the slag without diminishing its liminess, except the substitution of magnesia for part of the lime, as already described, and the addition of manganese within narrow limits. So for commercial work we must be satisfied to secure a compromise between fluidity, high temperature, and basicity. In cases of serious trouble the addition of fluorspar might doubtless be beneficial because its effect in lowering the free-running temperature of slags is extremely marked, but this is a subject which may be better discussed in a later article, it being impossible for commercial reasons to use fluorspar in normal operation.

Manganese has a much higher affinity for sulphur than has iron and the manganese sulphide formed is dissolved in the slag instead of the iron as the iron sulphide is. It is probable also that the presence of manganese oxide renders the slag more fluid just as oxide of iron does, hence the addition of manganese to the charge is beneficial to both the sulphur-carrying powers of the slag, basicity and fluidity, whereas lime is beneficial to one and highly detrimental to the other. It is, of course, out of the question to add manganese oxide to the charge as a flux, but a wide latitude of manganese contents is often to be found in ores of the same cost, and in such cases it is distinctly helpful to add manganese to the charge up to the limit set by the amount desired in the iron.

For economical desulphurization then we must have a reasonable volume of fluid slag, not too limey and preferably carrying some manganese. If the quantity of sulphur to be eliminated exceeds the sulphur-carrying capacity under these conditions, we must then go to increasing lime and increasing slag temperature or increasing slag volume or both, but in any event economy must be sacrificed.

We have then two methods whereby iron low in sulphur and also low in silicon can be produced. First: we can increase the lime, increase the blast temperature if possible, and increase the coke enough to offset the rapid rise of the critical temperature resulting from the more infusible slag. The hearth heat decreases in spite of the increased blast temperature and increased coke because the critical temperature increases faster than the coke ratio. All of this tends to make the iron physically hotter but chemically colder, that is to say, to lower the silica, and this result is of course greatly assisted by the hot excessively basic slag produced with its huge affinity for silicon. The result of making low-silicon iron by this means is to increase the fuel consumption. That is to say, it requires more coke and considerably more limestone to make an iron with 0.75 silicon than it does to make one with 1.50

silicon, because, as stated above, the critical temperature rises rapidly, with the consequences pointed out in the article on thermal principles.

On the other hand, we can work on the plan of making the slag just as fluid as possible, consistent with desulphurization, and then pile on burden, that is, additional ore, until the hearth heat per unit of iron is so reduced that the silicon can not rise above the limit desired.

The result of this method of operation is to reduce the fuel consumption, so that working on this basis it requires less fuel to make an iron of 0.75 silicon than it does to make one of 1.50, but it requires more careful furnace work and involves running on a smaller margin of safety.

When it comes to making irons of high silicon beyond 3 per cent we have no recourse but to increase the fuel ratio so that the hearth heat per unit of iron being high, a surplus is left, a part of which expends itself in reducing more silica. Of course, the surplus is not large because the increase in hearth heat is not really very rapid. The additional fuel is spent in trying to keep pace with the rise in the critical temperature necessary.

It is quite probable that above a certain point, probably four or five per cent silicon, the critical temperature ceases to be the free-running temperature of the slag and becomes simply the temperature of the iron at which it will absorb the required percentage of silicon. Here then we are at the disadvantage of no longer having the cinder to act as a retardant and assist in the work of heating the iron to the desired temperature by delaying its descent, and the efficiency with which we utilize the heat produced in these furnaces is therefore decidedly lower than any furnace on the ordinary range of silica. It is because we are without this retardant action that the hearths of furnaces on high-silicon iron are made smaller than those for steel-making and other moderate silicon iron. In order to obtain the heating of the iron desired we must give it a more intense and intimate contact with the hot gases as they arise from the hearth and this can obviously be done by narrowing the hearth and the base of bosh, in which this action takes place.

Above 15 per cent silicon the temperature necessary becomes so high that there is little or no hearth heat to be obtained above it and it becomes commercially impracticable to make higher silicon even by considerable further increases in the coke ratio.

In the range from 1 per cent to 3 per cent silicon, we change the product of the furnace from one silicon content to another by changing the burden and leave the slag ratio almost unchanged.

Manganese Control

Our control of manganese is not as complete as it is of some of the other elements. It is practically impossible to throw much more than about 80 per cent of the total into the iron except perhaps at low percentages, under 2 or 3 per cent; when, owing to the high solution power of the iron, a somewhat greater percentage of the total manganese charged may, under favorable circumstances, enter the iron. On the other hand, we cannot in practice secure its complete elimination, because with the furnace in proper working condition a certain percentage of the total amount charged always enters the iron in spite of our best efforts. With a furnace working cold, making white iron, and a thin scouring cinder, practically all the manganese is carried off, but as it is impracticable to operate a furnace this way commercially this fact is of no

real value in manganese control. It is safe to say that the lower limit of the manganese entering the iron in ordinary good practice is about one-third of the amount charged, and that in a general way the ordinary range of manganese content in the iron comprises from one-third to two-thirds of the amount charged.

Manganese is very much more active chemically than iron and therefore has a much greater tendency to act as a base, forming manganese silicate, and passing out in the slag. Its temperature of reduction, and also its heat of reduction, are considerably higher than that of iron, therefore in order to throw the maximum percentage into the iron the furnace must be very hot and the silica must be as completely satisfied as possible. Both these results are accomplished by making a very limey slag, the lime is a stronger base than the manganese and therefore when present in excess has a strong tendency to prevent the manganese from obtaining any silica with which to combine, though this action is not absolutely complete. On the other hand, as we have already seen, the effect of calcareous slags is to raise the temperature of the furnace, provided of course sufficient fuel be charged to supply the quantity of hearth heat required above this high temperature. In order to throw the manganese into the iron therefore we must use a light burden and a very limey slag. This tends to prevent the loss of manganese in the slag and to reduce it to the metallic condition, but the high heat here brings in a bad effect when high percentages of manganese are present, as the manganese vaporizes and for some reason does not recondense in the upper regions of the furnace, but passes out of the gas as a dense yellow fume. Furnaces working on ferromanganese can be recognized by their smoke for miles.

When it is desired to lower the manganese in the iron the opposite procedure must be followed. Lime in the slag is reduced to the lowest possible limits consistent with desulphurization so as to make a thin fluid slag, to keep down the hearth temperature, and to leave some silica relatively free so that it can combine with the manganese oxide and slag it off.

We have here those conditions of gradually shifting equilibrium of which I have so often had occasion to speak. The iron itself has an affinity for manganese on one side, while the slag, especially a siliceous slag, has an affinity for it on the other. High temperature shifts this equilibrium toward the iron side, but no conditions at our command enable us to reach either end of the scale. The affinity of the iron for the manganese never completely triumphs over that of the slag so as to absorb it all into the iron, while on the other hand it never falls so low that all the manganese can pass into the cinder under normal working conditions.

We have, however, a further means of controlling manganese to some extent. I have spoken of the action of a scouring slag, and we can to a certain extent produce such a condition in a normal working furnace by charging a certain amount of material which has a tendency to produce a scouring slag, such a material for instance as mill cinder. It is well known that metallic manganese will reduce iron from slag, the oxide of manganese produced by the reduction replacing the iron oxide in the slag. The effect of thus producing a scouring slag is to supply a certain amount of unreduced iron on which the manganese in the iron can work as it passes through the slag into the hearth, and by this action the manganese is lowered materially. By the use of this expedient in charcoal practice I have been able to produce iron on low manganese specifications that could not be made from the ores available

without the addition of mill cinder even with the most acid cinder we could use.

Phosphorus Control

This is extremely simple in one way because we know that when the furnace is operating properly 100 per cent of the phosphorus charged will enter the iron. As explained in the article on chemical principles a very scouring slag, such as made by a furnace completely deranged carries off as much as 10 per cent or even more of the total phosphorus charged, but while this is a matter of some scientific interest it has no bearing whatever on the question of burdening the furnace for commercial purposes.

In order, therefore, to produce an iron containing a given amount of phosphorus we must provide a charge which contains just that amount. This sounds simple enough, but when the phosphorus limits desired are very low it becomes a matter of great difficulty to secure raw materials so free from that element that the iron will not contain more than the amount specified. In the case of specially low-phosphorus or extra Bessemer iron described later, with specifications of 0.035 and under, this difficulty becomes extreme. For instance, if two tons of ore, one ton of coke, and half a ton of limestone be required per ton of iron, and each of these materials contains one-hundredth of 1 per cent, the resulting product will contain the maximum permissible amount of phosphorus, 0.035 per cent. Such raw materials are extremely rare and in consequence iron of this kind commands a premium of several dollars per ton over iron exactly analogous in other respects but a trifle higher in phosphorus.

The same condition holds good in regard to the Bessemer specification, but of course in a much less degree, because both on the theory of probability and as an actual fact the supply of a material of a given degree of purity increases very rapidly as the purity required diminishes, so that many thousand times as much ore are available for making iron of 0.09 phosphorus as are available for making it of 0.035.

On the other hand, the amount within the wider limit is a relatively small proportion of the total amount of iron ore in the world, and therefore Bessemer iron commands a premium of from one to two dollars per ton and Bessemer ore suitable for making it commands a corresponding premium diminishing as the use of Bessemer steel decreases.

The same conditions are true in regard to supplies of coke, but not to the same extent. Cokes contain as a general thing only small percentages of phosphorus, and while some premium is paid for cokes extraordinarily low in this element, it is small in comparison with the premium on low-phosphorus ores.

Turning now to the other end of the scale, there are produced great tonnages of iron in which the phosphorus must not be below certain limits, in ordinary foundry irons about 0.5 per cent, the production of this in a district of low-phosphorus ores, high-phosphorus material sometimes commands a premium. Extra-high-phosphorus ores are often hauled hundreds of miles for admixture with those of lower phosphorus when foundry or other high-phosphorus iron is desired, and in very many cases the phosphorus which the steel maker has been at such pains to eliminate from one iron to convert it into steel is charged back into the furnace in the form of open-hearth slag so as to increase the phosphorus in another iron. In some cases even phosphate rock is used to give the desired phosphorus, and one resourceful furnace-man in the Northwest, running a charcoal furnace on rather low-phosphorus ores, when he received an order for high-

phosphorus iron, produced it by collecting the beef bones from the surrounding lumber camps and charging them as flux.

For certain purposes steel must contain more phosphorus than is left in it by the basic open-hearth process and such steel is rephosphorized by the use of ferrophosphorus, a special product made at only one blast furnace in this country. The phosphorus in this material ranges from about 17 to 18 per cent, the raw materials being iron ore and phosphate rock, with silica as flux for the excess lime of the phosphate.

Control of Carbon

We know very little of the general subject of the carbon contents of the different kinds of iron and the obvious corollary is that we know very little in detail about methods for its control, but in a general way we do know that a large quantity of carbon in the hearth and high hearth temperature contribute to high carbon, and the opposite conditions to low carbon.

I shall later point out that an excess of hearth heat, which of course in itself tends to produce higher hearth temperature than would otherwise occur, tends to high carbonization, and a cold working furnace hearth on the other hand tends to lower carbon. In a subsequent article I shall describe a certain variety of charcoal irons, known as spotted irons, whose undesirable characteristics come from high carbon, and it was believed in the charcoal business before the cause of the iron's peculiarities was known, that this iron is produced by too small a slag volume and a limey slag. The small slag volume tends to leave an excess of hearth heat, and the limey slag tends to a high temperature, while the deficiency of heat in the shaft of these furnaces results in a comparatively large quantity of fuel in the hearth. Hence these conditions all make for high temperature, an excess of hearth heat, and a large quantity of carbon in the hearth. These are the three principal factors tending to high carbonization. This shows that there is close agreement between a rather vague belief developed, almost as tradition, through long years of practice and the fundamental principles set forth, is very good.

On the other hand, charcoal furnaces which work with low blast temperature, very fusible slags, and quite large slag volume, sometimes produce irons very low in carbon, down to 3.4 or the like, and this also is in agreement with the principles above laid down.

In coke irons the possibilities of variations in the conditions are less, and the limits within which carbon varies are correspondingly narrower, but I have been advised by Mr. John S. Kennedy, who has paid much attention to this subject, that by using a rather irreducible ore with a limey slag, and comparatively high fuel, he was able to maintain the carbon above 4 per cent even with silicon up to 3 per cent, although that percentage of the latter element is ordinarily high enough to cause some reduction in the carbon. This is in line, in a general way, with the principle set forth above and with charcoal practice. On the same basis one would expect a coke furnace running with a moderate volume of fusible slag, and on a comparatively fusible ore, to produce irons low in carbon, and while I have no exact data on this subject I believe it to be a fact that the irons made in Virginia on low-alumina fusible slags, and approximately under the conditions outlined, are lower in carbon than any other coke irons made in this country.

Oxygen Control

Definite knowledge of the quantity of oxygen in cast iron only dates back two or three years, and the views

set forth on its effects in a later chapter are by no means universally accepted, but their correctness has been demonstrated by a vast mass of facts, and they are accepted by some of the highest authorities, so that they will be considered as established.

Owing to the necessity of treating the subject of oxygen as a whole on account of its novelty, most of the data we have concerning oxygen control are included in the subsequent article on products, but a condensed presentation of the facts from the operating point of view is desirable here. The three principal factors in controlling oxygen are temperature, manganese, and the kind of ore used. The fact that oxygen could be present in cast iron, with its high content of carbon and generally with a considerable content of silicon and manganese, was not admitted until recently, because it was believed that these elements, any or all of them, would unite with the oxygen and carry it off instantly as an oxide.

As a matter of fact this is not necessarily true at all. If the temperature of the bath be kept low, considerable quantities of oxygen—from 1/20 up to 1/10 per cent—can remain in the iron, but as the temperature rises the affinity of the oxygen for the elements mentioned rises very rapidly so that more and more of it is removed as an oxide, and when we reach 2800 deg. or 2900 deg. only traces can remain in the bath.

This is another of those cases of continuously shifting equilibrium so often mentioned, and of the other law apparently almost as general in its application that iron has a much greater affinity for small quantities of all the elements we have discussed than it has for large ones, or perhaps we might say that the reactions which chemistry leads us to expect go on much more slowly as they approach completion and finally reach equilibrium before they are complete.

This difficulty of removing the final traces of oxygen may in this sense be considered as merely the final manifestation of the increasing difficulty of deoxidation as that process becomes more complete, as described in the articles on chemical and thermal principles. We must not ignore, either, the increasing dilution of the oxygen in the bath as it becomes more completely removed.

Next in importance to temperature come the quantities of silicon and manganese present in the bath, carbon being much less important and subject only to minor variations in percentage present so that its effect is approximately constant, whereas the others are subject to variations all the way from fractions of a per cent to several per cent. Manganese is very much more active than silicon in deoxidizing. An iron with 1 per cent Si and 0.5 per cent Mn can probably retain twice as much oxygen as one of 0.5 per cent Si and 1 per cent Mn; in fact, it is probable that only a trace of oxygen can remain with more than 1 per cent Mn, whereas appreciable quantities can be retained with 2 per cent or more Si when the manganese is low.

The third element in the control of oxygen is the character of ore used. Our experience in regard to this is not yet extensive enough to enable us to attach different values to the different ores as regards their oxygen-retaining power in any quantitative way, even the crudest, but there are certain unmistakable qualitative indications which should not be ignored.

I once had charge of a charcoal furnace which was normally operated on a plastic, soft hematite from the Gogebic Range. We decided to try a fine granular limonite from the Mesabi to see whether its greater reducibility would affect the quality of the iron.

Test bars were being taken from every cast and ranged fairly well together for the same grade of iron on the normal ore mixture.

As soon as a burden containing about 25 per cent of the Mesabi reached the hearth the strength of the iron dropped about 10 per cent. The result was so marked and so contrary to the results for which some of our officials hoped for that we repeated the whole experiment, with absolutely identical results.

We had not at that time begun oxygen determinations, so I have no absolute analysis to offer to prove that the oxygen dropped with the more reducible ore, but there is no doubt whatever that it did.

On the other hand, certain irons made wholly or in part from magnetite ore, both with charcoal and coke as fuel, have some of the strength, close-grain, and chilling power of charcoal irons, especially if made on a "raw" slag. It is undoubtedly on account of the oxygen which remains in these irons from the irreducible ore that they possess these characteristics. This has been proven by direct analysis in at least one case.

One plant running under these conditions has always produced iron of a high reputation for strength, and it has recently been extensively advertised as containing vanadium, to which its qualities are ascribed. Vanadium has undoubtedly been found in the iron in very small amounts, but its presence there is purely a coincidence and an unfortunate one, since if there were enough of it the result would undoubtedly be to deoxidize the iron and so destroy the very qualities which the vanadium is claimed to give. The fact is that the quantity of vanadium is too small to take up all the oxygen, while on account of the extreme dilution its action is by no means quantitative, and as a result sufficient oxygen remains in the iron to impart a slight increase in strength as compared with ordinary coke iron, and this oxygen is undoubtedly due to the burden of magnetic ore.

General experience taken in conjunction with these concrete cases enables us to say that other things being equal the most reducible ore produces the iron with the lowest oxygen content. If, therefore, we desire an iron low in oxygen, as is desirable for some purposes, we must run the furnace hot and limy on an ore as high in manganese as the other conditions will permit, and the ore must be of the most reducible kind. On the other hand, if we desire an iron high in oxygen, we must use an ore low in manganese and run on as thin and fusible a slag as will suffice for desulphurization. We should also use at least some fairly irreducible ore, magnetite, mill cinder, or the like.

These are general principles which apply alike to charcoal furnaces and to coke furnaces, but on account of the high temperature of coke iron brought about by the refractory slag on which it is made, the maximum quantity of oxygen which can be retained is smaller and the variations of much less importance than in charcoal iron, in which the minimum amount is as small as in coke iron, but the maximum several times as large. We shall see later that the low temperature at which the charcoal furnace can run (though it is often not so operated) on account of its fusible slag, is the reason for the great superiority of its product for some purposes.

We shall see in a subsequent article that we can control oxygen by treatment of the iron after it leaves the furnace better than by any method of operating the furnace. In other words, by operating the furnace to the best advantage and then giving the iron a further treatment external to the furnace we can achieve results out of reach by either method above. By proper treatment of suitable iron we can impart oxygen in greater quantities and under more complete control than can be produced even from a charcoal furnace, while for the limited class of work for which extra soft iron is desired we can produce it by superheating iron of proper com-

position in the electric furnace. The increase in temperature promotes those reactions which remove oxygen and sulphur and give the high temperature necessary for the formation of large flakes of graphite.

The Effect of Slag Temperature on Fracture

In the production of foundry iron arises a feature not covered by the analysis in the ordinary sense. This is the fracture of the iron. It is only about twenty years since all the iron used in foundry work was graded and selected entirely on the fracture and appearance of the pigs, and this custom prevails to some extent even yet. For some foundry purposes it is necessary that the iron be very "soft," which means that when it is melted with a large proportion of scrap iron, broken castings, and the like, it must be able to prevent the mixture from becoming too hard. The general belief of the trade was that iron having a large, coarse crystallization with very shiny crystals was soft iron, while that with fine, close grains was likely to be hard. For this reason foundry irons were very generally desired to be of the open-grained variety, and, in fact, irons not up to the standard in openness of grain were given a lower grade and brought a distinctly lower price in the market, a condition which prevails to-day.

It is therefore important that the iron shall not only have the silicon content desired for a given grade, but that it shall "grain out"; that is, have the openness of fracture which it is the custom of the trade to associate with that grade. We shall later see that sulphur is often responsible for closing up the grain of the iron, and it is undoubtedly on account of the rise of sulphur in the colder irons that a close grain is ordinarily associated with a poor iron. But even though the desulphurization be satisfactory, there are cases in which irons refuse to grade out in a way to correspond with their analysis. This is due, as we have seen and have occasion to emphasize in a later article, to the fact that the iron is made at too low a temperature to remove all its oxygen, and in such cases it is necessary to add lime so as to raise the fusion point of the slag, if the fracture of the product be kept up to match its quality, even though this has a desiliconizing influence on the iron which must be met by additional fuel.

This effect can be obtained in a much greater degree by electrical superheating after the iron leaves the furnace in cases in which the commercial conditions warrant the expense.

Other Occasional Elements in the Charge

In addition to the elements already mentioned there are several others which occur in some raw materials, generally the ore, in greater or less amounts. I have heard of cases in which barium occurred as a base, and when it does, allowance must be made for its fluxing action, which can probably be done tentatively on the basis of its being equivalent, weight for weight, to lime.

Barium sulphate is an occasional ingredient in ores, and is likely to cause trouble by increasing the sulphur from an unexpected quarter. Sulphur from this source simply adds to the total amount to be fluxed.

TITANIUM

There are also in some ores several other metals associated with the iron of which it is necessary to take account. The commonest of these is titanium, which has already been mentioned as an exceedingly common ingredient of many magnetic ores. This element has had a very bad reputation among furnacemen, and many ores have been kept out of the market for years by their titanium content.

The extensive experiments conducted by the McIntyre

Iron Company, and reported to the American Iron and Steel Institute by Mr. Bachman, have already been mentioned. Mr. Bachman states in his paper that the experimental slags made up were calculated on the basis that the TiO_2 was the equivalent in acidity to three-fourths of its weight of silica. He states that there is some reason to believe that the titanium is even less acid than this. Mr. Bachman's calculations were on the basis of considering alumina as an acid, and as this is at variance with the practice which I have recommended of considering alumina as neutral, allowance must be made for this fact in considering his conclusions. Slags containing as much as $22\frac{1}{2}$ per cent of titanic oxide were produced experimentally, and these seemed to have a fluidity almost as high as the corresponding slags without titanium. In practice on the furnace, however, it was not found possible to operate with slags as high as this on account of the tendency of the titanium compounds to build up in the hearth. There was, however, no trouble as far as shown by the several weeks of experiment in operating successfully on a slag containing several per cent of titanic oxide, and there seems to be no longer any reasonable doubt that it is quite possible to operate furnaces successfully on ores containing amounts of titanium which at one time were believed to have been prohibitive. Just what the commercial limits are can be determined in each case only by experience, not simply on test runs but on long runs in regular practice, and will depend not only on technical considerations, but on purely commercial ones, on the relative cost of titaniferous and non-titaniferous ores, their relative fuel requirements, outputs and the like.

It seems proper to note here the pioneer work done by A. J. Rossi, who more than twenty years ago became convinced that titaniferous ores could be worked successfully, and built a small blast furnace some 20 ft. high, on which he carried out a number of tests on these ores, and first demonstrated on an important scale that the ores could be used, and that the slag produced was fluid and could be handled without difficulty if calculated on the basis of titanic oxide as an acid. (See *Transactions A. I. M. E.*, Vol. XXI, page 832.)

As noted earlier a part of the titanium passes into the iron. The quantity obtained in the McIntyre tests ranged around a half of 1 per cent, being roughly constant with quite wide variations in the amount of titanium in the charge, indicating that this is approximately the saturation point of this element under ordinary conditions of temperature in the hearth, etc.

CHROMIUM

This element is unlike titanium in that most of it passes into the iron and but little into the slag. I am advised by Prof. J. W. Richards that the heat of formation of chromic oxide is probably about half that of silicon, so it is very much less than that of titanium. This, of course, facilitates its reduction and passage into the iron. This action is probably greatly assisted by the fact that chromium seems to form a very definite compound with iron and carbon, a double carbide of iron and chromium. This probably means that the iron or iron and carbon together have a more powerful solvent effect on the chromium than they have on titanium, which does not seem to have so definite an action, having a very much smaller effect on the character of the iron. Not much information is available as to the percentage of total chromium in the charge which passes into the iron and into the slag under different conditions. This is probably in part because merchant furnaces cannot use chromiferous ores except in small quantities, and have not therefore developed any information as to the possibilities of slagging it off, etc., the reason being the

very marked effect of chromium on the iron, 1 per cent making it quite hard, and 2 per cent making it entirely unfit for foundry purposes except as a small percentage of the mixture, and rendering the iron fit therefore only for steel works' purposes.

In small percentages nearly all the chromium seems to pass into the iron, but as the percentage rises more and more passes into slag, so that it is said to be impossible to produce in the blast furnace ferrochrome containing over 35 per cent Cr.

NICKEL

Nickel, like chromium, occurs very generally in laterites ores which are the breaking-down products of serpentine rock. Nickel is more reducible than iron, having a very low affinity for oxygen, and therefore all the nickel present passes into the iron, and like phosphorus it can only be controlled by controlling the amount in the charge. Nickel enjoys, however, the unique distinction of being the only element that is beneficial alike in iron and in steel, and there is never any reluctance to having it in the product, except perhaps reluctance to waste so valuable a commodity as nickel on a relatively low-grade product like cast iron, the value of the former being forty to fifty times greater per unit of weight than that of the latter.

COPPER

Copper, like nickel, is more reducible than iron, and all that is present in the charge passes into the iron alloying with it. The effect of this element on a product is generally considered undesirable, and therefore efforts are usually made to keep it out of the charge as much as possible. Some irons of good quality, however, contain as much as 1 per cent on the average, and more on occasion, while tests made by introducing as much as 2 per cent into crucible remelts have shown no effect whatever on the quality of the iron, so that this element has probably been unjustly condemned in the past.

VANADIUM

Vanadium is a metal very difficult to reduce when smelted alone, resembling titanium in this respect, but like the latter considerable fractions of 1 per cent pass into the iron if it is present in the charge. Vanadium is so very valuable that a content of a very few per cent of vanadium makes an ore more valuable for that than for iron, so that as far as known no experiments have ever been made as to the action of a considerable percentage of this element in the blast furnace charge. Little or nothing is known concerning its control.

Other elements, such as tungsten, tellurium and others, are undoubtedly sometimes present in ores of iron in small quantities, but the occasions are so rare and the quantities so small that nothing is known concerning their action.

It may be well to call attention to the fact that in some of the earlier works on metallurgy analyses are given showing considerable percentages of aluminium, calcium, and magnesium in the iron. It is safe to say that these results were due to errors of analysis, since these appear to be three elements which are not dissolved in cast iron to any extent whatever. Presumably the temperature of the furnace hearth and the affinity of the molten metal for them are jointly too small to throw any of them into the bath.

Burdening Without Chemistry

In the early days before chemistry was in universal use in the iron business the burdening of the furnace was done on a practical rather than a chemical basis, and even now it is so done at some isolated plants. The furnaceman learns by the general appearance of his slag the kind which suits his conditions, and with which his

furnace works the best. He learns from both the appearance of the slag and that of the iron to judge of the different grades of iron he produces, and whether, when he varies from it, the furnace is too hot or too cold. He accordingly increases or decreases the burden by an amount depending upon his judgment of what is required. Similarly, if the slag is too lean he adds lime according to judgment, and if it is too limy he removes it on the same basis.

This sounds rather crude at the present day, but much excellent furnace work, both as to regularity and fuel economy, was done on this basis, and it would be very much more correct to say that this was the foundation of furnace burdening and chemical control of the superstructure, than to say the reverse. Even with our advance knowledge of the composition of the coke, limestone, and ore, the factor of judgment can never be omitted or forgotten. Accidental variations arise, the coke is of poorer quality and dissolves more rapidly in the furnace, leaving less for the hearth, or the character of the coal changes in the mine and the coke becomes higher in ash or in sulphur, without notice, or a great mass of many million tons of ore on the Ranges, whose normal analysis is known to one-tenth of 1 per cent, contains an unknown variation from the normal at a certain point, and when in the progress of mining, steam shovels cut into this an ore different from that expected is shipped. These variations are largely eliminated in the mines of the Lake Superior region by careful analysis, sampling and sorting of cars at terminals before making up into cargoes, but in spite of this very considerable variations of the ore from the stated analysis occasionally arise. If nothing else happens an ore of one kind runs down from its own pile onto and over a pile of a totally different kind, and is taken to the furnace for the latter.

In all these cases the furnacemen must use the factor of judgment. The general characteristics of the slag can be quite accurately told by its fracture, especially if a sample of the cinder be poured hot into a small chill mold, since the sudden cooling tends to make the outside of the sample vitreous while the center is stony, and the depth of this vitreous layer in conjunction with other features of its appearance tells the furnaceman whether he is producing the slag that he needs or not. And if one had to choose between such tests of the actual slag, or an advance knowledge of the composition of the raw materials, it would undoubtedly be better and make for more successful operation to take the slag tests and let the analysis go, but the best operation can only be obtained by having both.

It is very desirable not to wait until the furnace has already made a "swing" that will take its product beyond the permitted limits, but to feel this swing coming and by taking quick action prevent it or break its force. This can be done by experienced men by methods which it would be difficult to put into words.

There is another factor in the burdening of the furnace, and in this chemistry has nothing whatever to do. This lies in the fact that the time required to bring through changes of one kind varies considerably from the time for changes of another kind, and the times required will vary within themselves according to the general conditions.

It seems an absurd statement, but a furnace really acts as if it had a reserve of heat, a sort of reservoir, upon which it can draw at need, so that when a bad condition arises for three or four hours, unless it is very serious the furnace is not thrown off its equilibrium, but if the same condition be kept up for half a day or longer the reservoir of heat appears to be exhausted and the furnace then becomes cold.

The same conditions apply to an even greater extent in the case of changes in the limestone burden than they do in changes of ore burden. If a sudden change be made in the character of the burden, for instance, if a more silicious ore be used, or less limestone be charged, it will be found that this change does not come through in the same period that is expected to show any change of ore burden. Generally it takes almost twice as long. On the other hand, if the furnace is running too lean and more limestone be added to the burden the effect of this will not appear for some time after the charge on which the change is made has come through. The furnace acts as though there were a thickness of lime or limy slag on the bosh walls which reaches an equilibrium with the conditions prevailing in the hearth and bosh, that is with the kind of slag that the furnace is making at the time.

I have always assumed that when the equilibrium between the coating on the walls and slag is altered the wall coating tries to make up for the deficiency. If the slag becomes more silicious the wall coating, being limier, gives up lime enough to bring it back to equilibrium. On the other hand, if the slag be made more limy the walls build up their limy coating again before the extra lime is permitted to reach the hearth. It is impossible to say if this is literally true, but certainly the furnace works as if it were, and in recent years I have always been accustomed to making a charge of lime twice as great for the first twelve or twenty-four hours as seemed to be needed. This provides the excess, whether positive or negative, required by the walls, and brings through the charge of lime at the proper time instead of many hours later.

Recent Chemical and Metallurgical Patents

Iron and Steel

Reduction by Liquid or Gaseous Media.—In a patent granted to JOHN W. BECKMAN of Berkeley, Cal., the inventor discloses his process of reducing iron or other metallic ores without the aid of solid carbonaceous reducing agent. The ore or oxide to be reduced is mixed with suitable fluxes and heated to a temperature near the melting point of the mixture. It is then transferred to an electric furnace and heated to about 2000 deg. C., when it becomes liquid. The liquid mass is then transferred to a converter of the Bessemer type, and gas obtained from the cracking of petroleum or the vapors from natural oils is forced into the converter through the liquid ore. The products are pure iron practically free from carbon, and a molten slag. Internal heat is supplied to the mixture during converting to supplant such heat as is dissipated by the gases driven off, this internal heat being provided by admitting with the reducing vapors a regulated amount of air. (1,160,822, Nov. 16, 1915.)

Reducing and Metallizing Iron and Other Ores.—The reduction of metallic oxides or carbonates, producing nodules of metal without fluxing the ore and making a molten slag, is the basis of patents granted to JOHN T. and ALBERT G. JONES of Iron Mountain, Mich. The patents are assigned to the New Metals-Process Co., of Chicago.

Earlier attempts at reduction and metallizing without fluxing and smelting were conducted in long tubular revolving furnaces. The type of furnace patented in the present invention is more on the line of a gas-producer, the hot gases from which are conducted to a tubular dryer through which the ore and fuel are fed to the furnace. The treated ore and unconsumed fuel are discharged at the bottom of the furnace into water, from which the floating fuel is recovered and

dried, while the ore is crushed and treated by jiggling for recovery of the metallic globules.

In practice the ore is crushed to a size which permits it to pass a screen of 1-in. mesh. The fuel may be coke, charcoal, wood or coal, and is mixed with the ore in greater proportion than is necessary for reduction of the metallic oxides. The proportion by weight may be two parts fuel to one of ore, and by volume, up to twenty to one. The intention is to afford opportunity for free draft and to keep the particles of ore well separated from each other and accessible to the reducing gases generated by the fuel. The atmosphere in the furnace is maintained in a reducing state, containing preferably carbon monoxide and hydrogen, so that the metal oxides may be converted into metal in nodular form without melting the slag-forming constituents. The furnace is operated preferably by natural draft, but pressure may be employed if desired.

In addition to iron ores, copper oxides and carbonates are amenable to the process. Manganese also may be produced in comparatively large globular masses. (1,174,727-28-32, March 7, 1916.)

Gold and Silver

Slime Agitator.—An improvement in the type of agitator commonly known as the "Parral" is patented by BERNARD MACDONALD of South Pasadena, Cal. The improvement consists in providing the circular tank with a bottom shaped as shown in Fig. 1, by the introduction of a central cone B and sloping side C.

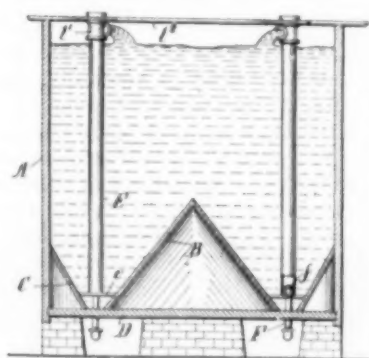


FIG. 1—SLIME AGITATOR

This construction forms a trough into which the settling solids are directed and again drawn up to the top of the tank through the air-lifts E. The latter discharge tangentially and cause a swirling motion of the tank contents, thereby keeping them in suspension and affording opportunity for dissolution of the precious metals in the cyanide solution. (1,163,097, Dec. 7, 1915.)

Copper, Lead and Zinc

Chloridizing Complex Ores.—The method proposed for treatment of mixed sulphide ores of copper, lead and zinc, containing also silver and gold, which was tested experimentally at Helena, Mont., is outlined in a patent recently granted to COURT C. TITUS and WILLIAM J. BARENSCHEER. A diagrammatic flow-sheet is given in Fig. 2. The dry ore is crushed to about eight-mesh, mixed with 5 per cent of dry sodium chloride, and treated with dry chlorine gas in a vessel that is heated externally to maintain a temperature above the melting point of zinc chloride. Sulphur, arsenic and antimony, if present, are volatilized as chlorides and condensed outside the vessel. The heavy metal chlorides, with the associated sodium chloride acting as a flux, collect in a melted condition in the vessel and may be tapped from the gangue. These chlorides are brought into solution in anode liquor from electrolytic cells, containing sodium chloride, free chlorine and oxychlorine compounds.

However the solution may be obtained, the object of the process from this point forward is to replace each

of the metal chlorides by sodium chloride, precipitating the metals as such or as compounds, with the result that the final solution is strong brine that may be electrolyzed, with or without previous concentration.

Iron and manganese are first precipitated by the addition of oxidized ores of zinc, such as carbonates and silicates, and sodium hypochlorite which is produced at a later stage of the process. The precipitate of iron and manganese is said to be in a form suitable for filtering by reason of the use of native zinc ores as a precipitate for iron. A further advantage in using native zinc ores for this purpose is that their zinc is easily recovered without the expense of chloridizing. From the clear solution obtained after filtering off iron and manganese, any gold and silver present are precipitated by metallic zinc. Lead, copper, cadmium and bismuth also are precipitated at this stage. In case

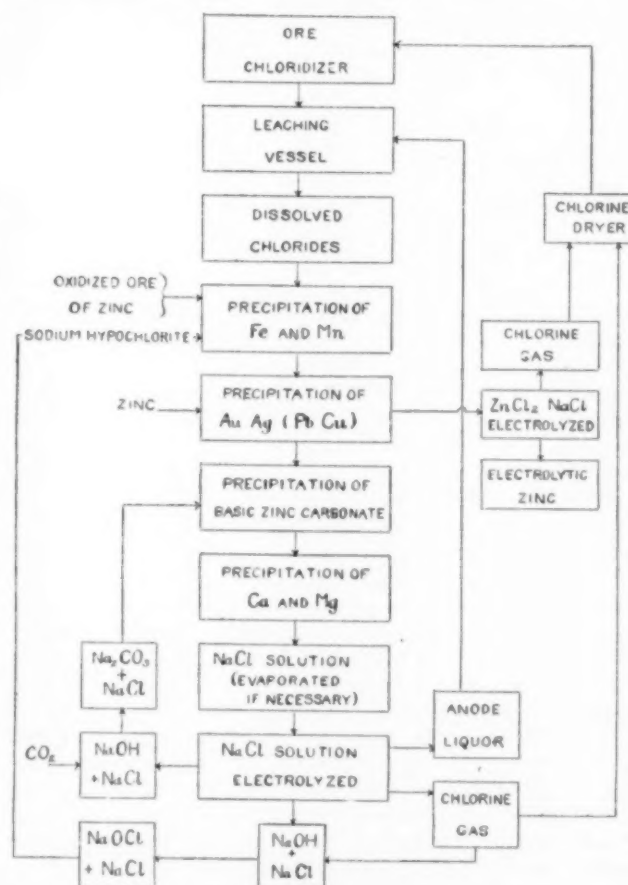


FIG. 2—CHLORIDIZING OF COMPLEX ORES

the original ore contains much lead, it may be advantageous to remove the bulk of that metal by cooling the solution and recovering lead chloride.

After precipitation of the precious and associated base metals the solution consists of the chlorides of sodium and zinc, with small quantities of calcium and magnesium chlorides. This solution is now treated with normal sodium carbonate to precipitate zinc as basic carbonate, care being taken to avoid precipitating the calcium and magnesium. The basic zinc carbonate is collected on filters, after which calcium and magnesium are precipitated by addition of more sodium carbonate, and finally removed by filtration. The remaining sodium chloride is now electrolyzed, the various products being used as follows: chlorine is dried and returned for the treatment of more ore; caustic solution is converted into normal carbonate by treatment with flue gases previously purified, and is used as a pre-

cipitant for the zinc solution; the chlorinated anode liquor is used for leaching. (1,173,467, Feb. 29, 1916.)

Recovering Copper from Tailings.—A proposal to recover copper from the tailing piles of the so-called "porphyry" copper concentrating mills is patented by RICHARD M. ATWATER, JR., of Scarsdale, N. Y. The tailings under consideration contain a large percentage of their copper in the form of carbonate, silicate and oxide which has escaped recovery by concentration. The inventor estimates that the tailings contain from 5 to 15 lb. copper per ton, of which 4 to 10 lb. is in the form just mentioned. This copper is soluble in sulphuric acid, and it is proposed to recover it by spraying the piles with sulphuric acid solution and then allowing the dissolved copper sulphate to come to the surface by capillary action. This would result in concentrating the copper in a comparatively thin surface layer of the pile, from which it could be scraped by hand or mechanically and removed for further treatment. As a rough approximation of the quantity of acid to be used, one might begin with a solution per ton of tailing, containing as many pounds of acid as there is copper per ton in the tailing; or, in other words, pound for pound. The tailing pile would be leveled and laid out in blocks or plots that could be served by a light industrial railway carrying the acid solution. The latter would be sprayed on the surface, after which the plot would be allowed to dry out. This would result in bringing to the surface an efflorescence of copper sulphate in concentrated form which could be collected by scraping. The method is facilitated by a dry or desert climate, and suggests the process adopted at certain cyanide mills in Nevada, where cyanide tailing dumps are sprayed with water and allowed to dry, resulting in bringing to the surface the precious metals that have been dissolved by the cyanide discharged with the tailing. (1,175,331, March 14, 1916.)

Duplex Smelting Process for Zinc Ores.—A method of interrelating the standard retort process of smelting zinc ores with an electrical process, whereby the efficient factors of each method are retained and the inefficient factors dispensed with, is patented by Messrs. WOOLSEY MCA. JOHNSON and EDWIN W. HALE of Hartford, Conn. The electrical step in the method is preceded by certain other conventional steps which will extract the metallic value involving a higher electrical cost of recovery, and which will so condition the material as to bring it into the state best adapted for a high efficiency in the electric furnace step. Thus the retort furnace makes the first two-thirds of its spelter with one-third the total metallurgical effort, and expends two-thirds of the energy in extracting the last third of the spelter. Conditions in the electric furnace are the reverse of this; that is, the electric furnace attains its highest efficiency on mixtures such as exist in the retort furnace during the low efficiency period. Hence the adaptability of a duplex process for the treatment of high-grade ores containing, say, 60 per cent zinc.

The first stage treatment of the inventors' process would consist in retort smelting with a lower percentage of coal and at a lower temperature than customary, and the production of a residue higher in zinc than usual. In the second stage treatment this residue would be mixed with low-grade zinc ore containing considerable iron, and with necessary slagging fluxes. In addition to the fixed carbon contained in the residue, hydrocarbon in the form of coal would be added, and the whole would then be smelted in an electric furnace of the Johnson type after the preheating which is recommended as a part of the process. (1,165,371, Dec. 31, 1915.)

Flotation

Preferential Flotation of Minerals from Mixed Sulphide Ores.—According to a patent granted to HENRY H. GREENWAY of Clare, South Australia, and ALFRED H. P. LOWRY of Prahran, Victoria, Australia, various metallic sulphides can be separated from each other in the flotation process by modifying the circuit liquor with a salt of chromium, such as sodium or potassium bichromate. Another method of treatment is to digest the sulphides with a chromium salt solution before flotation. The following examples are given: From an ore of molybdenum containing 15 per cent MoS_2 and 25 per cent FeS_2 , the flotation product contained 93 per cent MoS_2 and 4.9 per cent FeS_2 . In making this test the ore was crushed to 100-mesh and agitated with four times its weight of water at 120 deg. Fahr., containing in solution 0.25 per cent sodium bichromate and eucalyptus oil in proportion of 1 lb. per ton of ore treated. A copper ore containing 6.5 per cent copper and 35 per cent iron yielded a float containing 19 per cent copper and 30.2 per cent iron, with a tailing of 0.7 per cent copper and 36.2 per cent iron. A lead-zinc slime containing 18.6 per cent lead and 32.2 per cent zinc was digested for 30 min. in warm water containing 1 per cent sodium bichromate. On agitation with eucalyptus oil, 1 lb. per ton, this slime yielded a flotation concentrate containing 47.2 per cent zinc and 6.3 per cent lead, and a residue of 31.6 per cent lead and 16.3 per cent zinc. In most cases the best results are obtained at a temperature of from 120 to 150 deg. Fahr. (1,102,738, July 7, 1914.)

An improvement on the method of Greenway and Lowry is patented by HENRY LAVERS of Surrey Hills, Victoria, Australia, who states that the results obtained by the use of sodium or potassium bichromate are greatly improved if the water is made slightly alkaline, as by the use of sodium carbonate equivalent to 1 per cent by weight on the ore. The inventor finds that by using the ordinary agitation froth process in alkaline water he gets practically all the metallic sulphides, which may then be separated from each other by re-treatment in solution containing the chromium salt. A temperature of 130 deg. Fahr. is indicated. The following example is given: Slime containing 11.6 per cent lead and 13.4 per cent zinc was treated by the agitation froth process in alkaline water, yielding a concentrate containing 22.2 per cent lead and 27.4 per cent zinc. This concentrate was then subjected to preferential flotation in alkaline solution with the addition of sodium bichromate to the extent of 6 lb. per ton, kerosene equal to $\frac{3}{4}$ lb. per ton of concentrate and eucalyptus oil equal to about $\frac{1}{8}$ lb. The flotation product contained 48.6 per cent zinc and 7.5 per cent lead, while the residue contained 8.9 per cent zinc and 55.9 per cent lead. (1,142,821, June 15, 1915.)

Preferential Flotation of Galena and Blende.—A process patented by THOMAS M. OWEN of Sydney, New South Wales, Australia, is based on the discovery that the addition of minute quantities of potassium permanganate to slime which contains a mixture of lead and zinc sulphides will permit a separate flotation of the two minerals. The quantity of permanganate used is less than the quantity required to oxidize the reducing agents present in the slime or the water. The chemical is not added to the water used for treatment, but to the pulp of slime and water. Normal temperatures may prevail, or the process may be conducted at a temperature of 120 deg. Fahr. when the slimes are of a highly reducing character and likely to decompose the permanganate rapidly. The process is primarily useful on weathered slime, even a short weathering of a few hours being found advantageous. In some cases

a deadening agent, such as sodium hydrate, may be used to intensify the tendency of the minerals to float separately.

In carrying out the process the slime is mixed with non-acid water, agitated, treated with potassium permanganate followed by the frothing agent. The mixture is then treated by froth flotation, with the result that the lead floats. The residue is then resubmitted to froth flotation after acid (15 lb. H_2SO_4 per ton of slime) has been added, with the result that the zinc then floats. In practice the two flotation liquors, for lead and zinc, are kept in separate circuits, fresh water being added to the first circuit in which no acid is used. By way of example of the results obtainable, the following is cited: A weathered slime from Broken Hill contained 16 per cent lead, $13\frac{1}{2}$ per cent zinc and 17 oz. silver per ton. In this treatment, $2\frac{1}{2}$ lb. potassium permanganate and 3 oz. eucalyptus oil were used per ton of slime. A lead concentrate was first obtained, carrying 60.5 per cent lead, 54 oz. silver and 11.8 per cent zinc. After adding acid and retreating, a zinc concentrate was obtained containing 6.2 per cent lead, 11.2 oz. silver and 43.4 per cent zinc. The final residue contained 2 per cent lead, 3 oz. silver and 1.6 per cent zinc. (1,157,176, Oct. 19, 1915.)

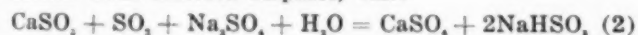
Synopsis of Recent Chemical and Metallurgical Literature

Chemical Engineering

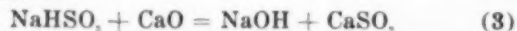
Utilization of Nitre-Cake.—An interesting description of a method for the utilization of nitre-cake by Dr. J. GROSSMANN appeared in the *Journal of the Society of Chemical Industry*, Feb. 15, 1916. It is well known that calcium hydrogen sulphite, known in commerce as bisulphite of lime, is decomposed by sodium sulphate as follows:



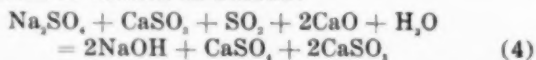
A similar reaction takes place if sulphur dioxide is passed through a solution of sodium sulphate which is mixed with calcium sulphite, viz.:



If now the insoluble calcium sulphate is separated from the liquid part, a solution of sodium hydrogen sulphite is obtained, from which by adding lime, caustic soda is obtained in solution, and a precipitate of calcium sulphite:



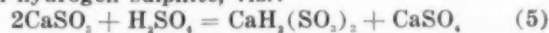
But for every equivalent of calcium sulphite which was originally used we obtain back two equivalents, so that one equivalent is wasted. This appears clearly if the equation is written as follows:



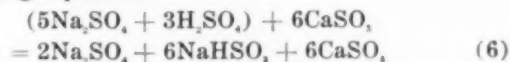
This waste is one of the reasons why this reaction, which was first proposed nearly forty years ago, has not been used for the technical manufacture of caustic soda. For not only must one equivalent of calcium sulphite be removed from the cycle of operations, but the addition of one equivalent of sulphurous acid which this involves complicates the working, and adds to the cost of the plant and process.

If a solution of nitre-cake is used instead of a solution of sodium sulphate, the reactions which take place are more favorable for practical results. Nitre-cake is theoretically a mixture of sodium sulphate and sodium hydrogen sulphate, which for practical purposes is generally looked upon as a mixture of sodium sulphate and free sulphuric acid. Thus, for example, a nitre-cake showing by test about 30 per cent of free sulphuric acid

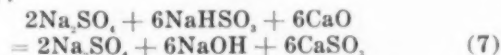
could be expressed by the formula, $5Na_2SO_4 + 3H_2SO_4$, which corresponds to 70.7 per cent Na_2SO_4 and 29.3 per cent of H_2SO_4 . It is well known that calcium sulphite can be decomposed by sulphuric acid so as to yield calcium hydrogen sulphite, viz.:



Thus the free sulphuric acid produces the same effect as the addition of sulphur dioxide in equations (2) and (4). A solution of the nitre-cake mixed with calcium sulphite would therefore decompose according to the following equations:



and further:



It will be seen that we finish up in equation 7 with the same quantity of calcium sulphite with which we commenced in equation 6, so that theoretically the original amount of calcium sulphite used would be sufficient for any number of operations. The solution after separation from the calcium sulphite contains mainly caustic soda and sodium sulphate, the latter free from iron and other impurities which have been removed by the lime in the causticizing process. On boiling down, sodium sulphate is fished out, and the final liquor is either used as such or further concentrated and made into solid caustic soda. Incidentally, I may mention that the calcium sulphate produced may possibly be made into pearl hardening, and thus yield a third commercial product.

In practical work it is, of course, not possible to obtain the results as shown in the above equations; a certain amount of calcium sulphite will have to be replaced, requiring the use of lime and pyrites, and the yield in caustic soda, so far as can be judged from laboratory experiments and other considerations, will probably only be two-thirds of the theoretical quantity, so that from 100 tons of nitre-cake about 36 tons of pure sodium sulphate and 15 tons of caustic soda as NaOH would be obtained. The cost of lime and of replacing calcium sulphite would amount to somewhere about £50, that of labor to about £40. About 400 tons of water would also have to be evaporated which, with steam for power, would require about 80 tons of coal, though in multiple effect less than half that amount should be sufficient. Taking it, however, at its worst, with coal at £1 per ton, the charge for fuel would amount to £80, bringing the total expenditure to £170. As the plant would be extremely simple and, without multiple apparatus, cheap, a further £10 per week for depreciation and other charges should be sufficient, so that a total expenditure of £180 per week, at present prices and with crude plant, should be sufficient to work up 100 tons of nitre-cake.

Against this must be considered the revenue to be derived from the sale of caustic soda and sodium sulphate. The sodium sulphate obtained by this process would be purer than saltcake, and should therefore, under equal conditions, realize at least the same price. The price of saltcake at present is £2 2s. 6d. per ton, at which price it is practically unsalable. If we consider that soda ash is at present sold at £3 2s. 6d. per ton, its equivalent in sodium sulphate is less than £2 6s., so that there is not much inducement for glass-makers to buy it at present prices. I therefore take the price of sulphate of soda in my calculations at only 25s. per ton naked at the works, at which price one could reasonably expect to be able to compete with soda ash where it can replace the latter, and the revenue from this source would therefore be on 36 tons £45 per week. The price of 70 per cent caustic is at present an un-

known figure, but ranges from £16 or £17 per ton up to £20 per ton and more. Taking pure caustic, on which these calculations are based, at £14 per ton naked at the works, the revenue from this would amount to £210 per week, and adding the two products together, we have a revenue of £255 per week against an expenditure of £180, leaving a margin of £75, or 15s. per ton of nitre-cake.

Any new process which is to be taken up in these exceptional times, however, should not only show a reasonable profit under present circumstances, but should also prove to be practicable under more normal conditions, though at present it appears most unlikely that for many years, at any rate, we shall have such low prices as we have had in the past. Now it will be seen that the chief expenditure in this process is coal, and that once the feasibility of the process has been established, it would pay to put up more expensive plant in the shape of multiple effect evaporators. That alone would effect a reduction of £50 per week in the expenses. At the same time, the expense for lime and for replacing calcium sulphite and other chemicals would be reduced by at least one-third, causing a saving of about £20, so that with the reductions in these two items, not reckoning any reduction in the cost of labor, we should have an expenditure of £110 per week. Against this, we should have a revenue from sodium sulphate, which should be the same as before, £45 per week, and 15 tons of caustic soda at, say, £9 per ton, i.e., altogether £180, leaving a margin of £70. It thus appears probable that the expenses would be less in proportion as the prices of the materials obtained became reduced, and that the process, which is provisionally protected, would, even in normal times, yield sufficient profit to render its use practicable.

Nothing was allowed for the cost of the nitre-cake. Most works were only too glad to get rid of it, and some might even pay for having it removed. On account of freight expense, it would be advisable to install the works near to those where the nitre-cake was produced. It was necessary to work with somewhat more dilute solutions than in the causticizing of sodium carbonate. It was not to be expected that during war time anyone would put up a costly plant. It is likely that at present ordinary methods of evaporation would have to be adopted, though even then the cost of evaporation would not be prohibitive. With multiple effect apparatus the cost of evaporation would not differ much from that incurred in the manufacture of caustic soda from sodium carbonate or Leblanc soda lyes.

Saline Method of Water Flow Measurement.—In the *General Electric Review* for February, 1916, W. D. PEASLEE gives a description of a method of water flow measurement by the use of salt which has been in use by several large operating companies for measuring the water taken by their power turbines. The method depends upon the introduction at a constant rate of a dosing solution made of salt, with subsequent mixing and then the sampling at a point further on in the stream. The samples are analyzed and from the amount of salt per unit volume the amount of water passing (rate of flow) can be calculated very easily, since the amount of salt added per unit time is known. The relation does not depend on the cross-sectional area of the stream or on any velocity determinations, and results depend on the following conditions:

- (1) Amount of salt per unit volume in samples taken.
- (2) Constant dosing rate.
- (3) Perfect mixtures.

Two methods are given by the author for analysis of the samples, the volumetric titration method using silver nitrate, and the conductivity method, using elec-

trolytic determinations of the resistance. The titration method is stated to give an accuracy of 0.1 per cent with a little experience but the conductivity apparatus as developed by the author is simpler and more easily carried about. It consists of a U-tube with platinum electrodes, a conductivity meter and a continuous current hand-driven dynamo. A curve of correction factors for temperatures is necessary as the conductivity varies with the temperature. The instrument is calibrated with standard salt solutions and can be packed in a portable case.

To secure a constant flow of dosing solution a standard orifice is used, and it has been found that any pump, rotary or reciprocating, will effect a perfect mixture as will a water wheel or turbine.

Ore-Dressing

Concentrating Molybdenite.—The dressing of molybdenite ores in New South Wales, Australia, is not up to the standard attained in this country, if one may judge from a description of operations given in the *Australian Mining Standard* for March 2, by E. C. ANDREWS.

The process, in the main, consists in crushing and dry screening. Experiments in water and oil flotation are being conducted, but no large tonnage has as yet been treated by these methods. Where the ore consists of molybdenite flakes of moderate size in quartz, the rock is crushed and the larger flakes of mineral sorted by hand, while the smaller grains are saved by hand screening. At larger deposits, where the ore contains bismuth mineral with the molybdenite in a clean gangue of quartz or silicious granite, more elaborate screening methods are employed. For instance, at one mill of 5 tons capacity the ore is crushed to 1-in. size by jaw breaker, further reduced in rolls and then screened to recover the larger flakes of molybdenite. The screen oversize is again rolled and screened, the holes in the shaking screens being 1/12 in. in diameter. The undersize passes onto a Wilfley table to recover the bismuth; the undersize is further crushed to 1/20-in. size and again screened by hand, obtaining a high-grade molybdenite in the oversize.

At one mill oil flotation is in operation. The oiled pulp is delivered into horizontal shaking troughs discharging into boxes filled with water. The molybdenite floats and is discharged into launders leading to a 180-mesh screen, which separates the valuable product. The apparatus is arranged for fourfold treatment of the ore by successive treatment of the tailings in the manner just described.

The History of a Prominent Metallurgical and Industrial Engineering Firm

Announcement has been made of the incorporation of The Dorr Company, successor to The Dorr Cyanide Machinery Company, as a result of the expansion of its business and professional service, due to the increasing use of Dorr machinery in so many varied processes and industries. The Dorr Company has taken over the patents and commercial business of its predecessor, and will act in a consulting capacity in connection with the design, construction and operation of hydrometallurgical, wet chemical and allied industrial plants and the conduct of technical investigations.

John V. N. Dorr, the president of the company, was born in the Oranges, N. J., and educated as a chemist. After several years in industrial chemical research (including two years in the laboratory of Thomas A. Edison), he went West and engaged in metallurgical work. He obtained his cyanide experience largely in the Black Hills, South Dakota, where after a period as

chemist he leased and operated a custom cyanide plant under the firm name of Lundberg & Dorr, and later erected and operated the first plant (the Lundberg, Dorr & Wilson Mill) to use continuously and successfully the Moore filter. In this mill the Dorr classifier was developed. It was designed and first used for making a separation of clean sand for leaching in tanks from slime for treatment by decantation or filtration. Other operators who saw it wished to use it, and its manufacture was commenced in 1906.

The development of filtration brought with it the "all-slimes" process and the classifier was then used in closed circuit with tube mills for making a product from 100 to 200 mesh. The introduction of the flotation process created a demand for milling a 40 to 80-mesh product in copper, zinc and lead mills, and the classifier has been used for this purpose with ball mills by such companies as Anaconda and Inspiration. The recognition of the need of desliming before hydraulic classification and tabling involved its use for that purpose. It was also apparent that it could be used for dewatering tailings, and it has been so used. The standard machine was originally designed to handle 100 tons, but the duty demanded has increased, and machines with a total feed of 1200 tons a day are now in use separating at 48 mesh, while one-fourth-size machines to handle a few tons a day are also made.

In 1906 Mr. Dorr invented his thickener when remodeling the mill of the Mogul Mining Company, also in the Black Hills. In 1907 he moved to Denver and arranged for the manufacture of both machines, although giving most of his time to consulting work and the operation of mills in South Dakota. As the classifier and thickener became known through wider use, the demand for them increased rapidly, especially in Mexico and the United States. No advertising, however, was done until over 200 machines were in use.

In 1910, on account of the growth of the business, The Dorr Cyanide Machinery Company was incorporated.

In 1911 the London office of the company was established, with Mr. William Russell in charge. During the same year an engineer, Mr. H. N. Spicer was sent around the world in the interests of the company. The introduction of Dorr machinery in India, Australia and other places followed. A by-product of this trip was Mr. Spicer's series of articles on the evolution of methods for handling slimes in India, New Zealand, Australia, South Africa and Rhodesia, published in METALLURGICAL AND CHEMICAL ENGINEERING, Vol XI, pages 181, 239, 315, 408, 451, 481, which our readers will surely remember with pleasure.

The Dorr thickener was first used in cyaniding to replace large cones and intermittent settling where grinding in solution was done. Its value was appreciated immediately and it has been installed very extensively throughout the world.

The advantages of a change in solution for assisting dissolution, especially on silver ores, and the losses that were found most common in filtration called for the extension of the thickener to counter-current decantation, either with a single displacement for increased dissolution or with four or five to supplement or entirely replace filters. The development of the Dorr tray thickener in 1913 reduced the objection of large ground space required for counter-current decantation, and on small plants has still further simplified matters by allowing the substitution of two slightly deeper tray tanks for four normal ones.

To the concentrating man the thickener did not appeal so readily because it frequently was considered that the small cone with its feed to the individual tables

was better suited to concentrating conditions. However, the development of slime treatment methods, especially flotation, caused its introduction, and within the last three years practically all of the well-known copper, zinc, and lead districts have adopted it. Used originally for producing a flotation feed of the proper density, it has been further utilized for thickening flotation concentrates before filtration and the recovery of water from flotation and other tailings.

The use of Dorr thickeners in industrial work has increased, and they are now used in rubber recovery, caustic soda production, and in many other places where the separation of finely divided material is required.

The original thickener was operated on classified slime in a tank 35 ft. in diameter. The size of tanks has been rapidly increased, and there is now in use a thickener in a concrete tank 130 ft. in diameter, while one for a 200-ft. tank is under construction. It has been developed to handle as coarse a product as 40 mesh.

The Dorr agitator introduced in 1912 is operating in nearly all of the well-known cyanide mills erected since that time in the United States and Canada, and many have been shipped to South America and the Eastern Hemisphere.

The classifier, thickener and agitator all operate continuously with exceedingly small costs for power, maintenance and attention.

About this time the introduction of the continuous counter-current decantation system with the use of Dorr thickeners in cyaniding attracted the attention of metallurgists, the first installation being made at the mill of the Vulture Mines Company in Arizona by Mr. Dorr. The further increase in the business and the opportunities for the application of Dorr machinery in various industries other than metallurgy led to the opening of a New York office about the end of 1913, and the expansion of the company's quarters in Denver.

Mr. Dorr has remained continuously connected during this development with the operation of one or more mills, and the company has been in close touch with a large number of plants, so that the development and improvement of its machinery has been handled from the viewpoint of the mill operator.

The company, during the last few years, has designed a number of mills, and among them the Vipond cyanide plant at Porcupine, Ont., the Rochester Mines Company at Rochester, Nev., and a cyanide plant for the South American Development Company in Ecuador. The description of the Rochester mill by our Western editor, published elsewhere in this issue, will be found particularly interesting.

During the last year the company financed, designed, and erected a mill for the Elko Prince Mining Company at Midas, Nev., and is now operating the property for that company.

The consulting department of The Dorr Company, through keeping in close touch with the latest developments in metallurgy, is equipped to render progressive service in the design and erection of plants and the investigation of processes, and to supervise the operation of a limited number of properties. Service of this kind is valuable not only to those property owners who are more interested in results obtained than in the type of equipment required to accomplish them, but also to those who do not find it possible to retain the entire services of men capable of efficiently designing or operating their plants.

The general offices and headquarters for metallurgical and industrial work will be at Denver and at New York City, while the London office and the Australian agency will be maintained as before.

Mr. A. L. Blomfield, for the past eight years superintendent of the Golden Cycle Mill at Colorado Springs, has recently become affiliated with The Dorr Company, but retains charge of the Golden Cycle Mill as general superintendent. The mechanical engineering staff of The Dorr Company has at its head Mr. W. A. Neill, who, for the previous eleven years, was chief engineer of the mining department of the Allis-Chalmers Manufacturing Company. Mr. H. S. Coe has charge of the laboratory and research department for the company. Mr. P. M. McHugh is the metallurgical sales manager for the company, while Mr. H. N. Spicer will continue in charge of industrial work at New York. Mr. Wm. Russell, a metallurgist formerly with the McArthur-Forrest Company, who has been in charge of the London office since it was started, will continue there.

Fluid Meter for Steam, Water and Gases

The measurement of steam flow is one of the most difficult engineering problems that has ever been attempted. It resolves itself into two distinct parts: first, to obtain a pressure difference that varies in a known and definite manner with the rate of flow, and, second, to accurately measure, record and integrate the rate of flow by means of this pressure difference. In a very extended investigation carried out by the Bailey Meter Co. of Boston, Mass., a great many experiments were made with Pitot tubes and multiple-hole nozzles, and many variations in their design were tried. They

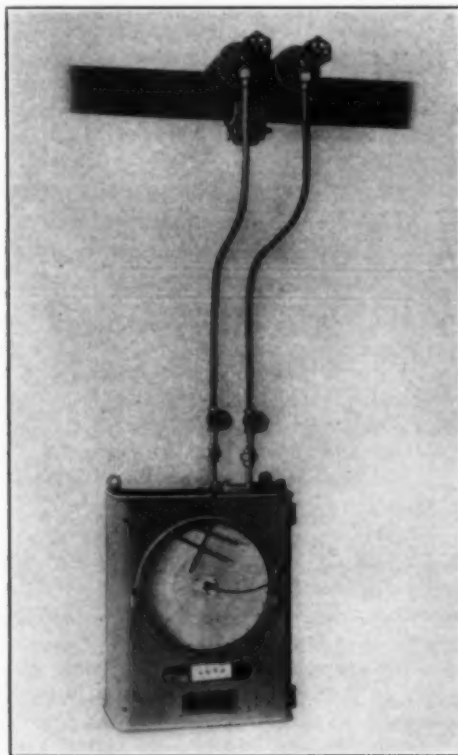


FIG. 1—METER PLACED FOR STEAM MEASUREMENT

proved to be unreliable in all cases except in long runs of straight pipe, and even there the latter did not maintain their accuracy for any reasonable length of time.

After very extended investigation a special type of orifice was devised, which furnishes a good means of securing the required pressure difference. It has the advantages of low cost, being easily installed and of giving constant accuracy over very long time. The size of the orifice is properly proportioned to the size of pipe and the meter capacity desired, so that the stand-

ard recorder can be used from the lowest to the highest velocities without changing the piping in any way.

The pressure loss caused by the orifice is never more than about one pound, which is less than that caused by an ordinary elbow, globe valve, or non-return valve with present-day velocities. A great deal of testing and calibration work has been necessary to determine the coefficients of flow for orifices of different diameter in the various sizes of pipe. This experimental work has been extended over several years in order to prove that there was no change in accuracy.

This meter works upon the principle of accurately

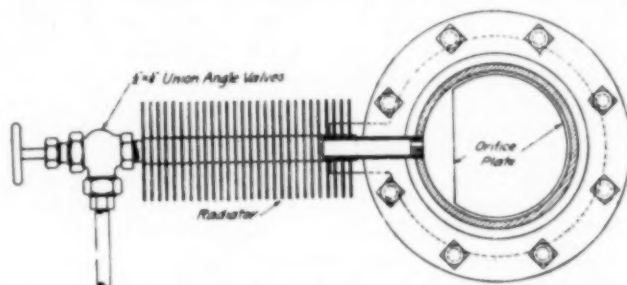


FIG. 2—SEGMENTAL ORIFICE AND RADIATOR IN HORIZONTAL PIPE

measuring the pressure difference across an orifice placed between a pair of flanges in a pipe line, as shown in Fig. 1.

The special orifice plate which is used is made of 1/32-in. Monel metal and is corrugated near its outer edge so that it forms its own gasket without any other packing or thickening up of the joint in any way. The size of the orifice is proportioned to the size of the pipe, the quantity and density of steam or other fluid flowing through it, so that about 1/2-lb. pressure drop is secured at average rates of flow. With this small pressure drop no cutting action occurs, and the orifice plate is entirely free from corrosion.

A sectional view of an orifice installed in a horizontal pipe is shown in Fig. 2. This particular orifice is of segment shape, which is used in high-velocity work, so as to secure the correct pressure difference without undue obstruction.

Circular orifices of relatively smaller diameter are used for lower capacities. In such cases a small drain hole is located in the orifice plate at the bottom of a horizontal steam pipe to prevent any accumulation of water.

When metering steam it is necessary to have the bell casing and connecting pipes completely filled with water up to an equal and constant level. Each time the bell rises or falls some water is drawn down in one pipe and an equal volume forced up in the other. It is practically impossible to have large enough reservoirs on a level with the steam pipe connections to answer this purpose, but the radiators shown in Fig. 2, consisting of a horizontal piece of 1/2-in. copper pipe with a number of washers or fins, serve to keep the water level and at substantially equal temperatures in the two connecting pipes.

Fig. 3 shows in detail the construction and operation of the Bailey fluid meter. The higher and lower pressures from the up-stream and down-stream sides of the orifice are connected to valves *H* and *L* respectively. Valve *B* is a by-pass which serves to equalize the two pressures when desired. From valve *H*, the higher pressure is conducted through pipe 90 and tube 117 to the space within the mercury-sealed bell. From valve *L* the lower pressure is conducted through tube 118 to the interior of the casing, which is subjected to full

pipe-line pressure of the steam or other fluid being metered.

The liquid shown in the reservoir is mercury and the entire casing and piping are completely filled with water at all times when used as a steam or water meter. The bell is entirely closed, except at its lower end, which is sealed by the mercury contained in the reservoir, so that the pressure H , applied through tube 117 to the space within the bell, which is in excess of the pressure L , applied through tube 118 to the space without the bell, tends to push the bell upward in proportion to the pressure difference. This pressure difference acts as if applied to a piston having the area of the inside of the bell at the surface of the mercury. In the normal or zero position of the bell it is almost completely submerged in the mercury, and is held in the mercury by the bell-weight, supported by a yoke fastened to the top of the bell. An increase in pressure difference forces the bell upward, and as it rises out from the mercury the change in the buoyant action of the mercury on the walls of the bell exactly balances the force due to the pressure difference. By suitably varying the area of the bell and also the thickness of its walls the resulting motion can be varied in any desired manner.

The shape of the bell in this meter is designed in accordance with the actual flow curve corresponding to the

pressure difference and rate of flow through the orifice, so that a direct reading chart with uniform graduations is used and the proper integrator motion is secured without adding one iota to the friction or complexity of the mechanism. The flow curve is similar to a parabola, and there is relatively much less head or pressure difference at low rates of flow than at the higher rates. For instance, the head available to operate the meter at 10 per cent flow is about 1 per cent of the head at

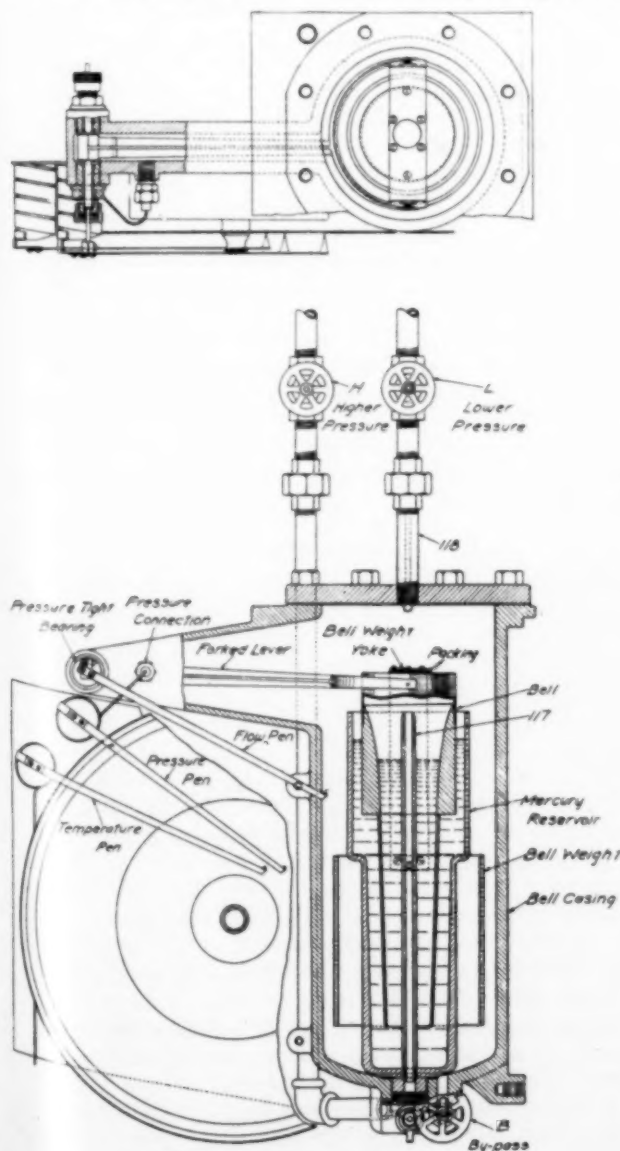


FIG. 3—CROSS-SECTION OF METER

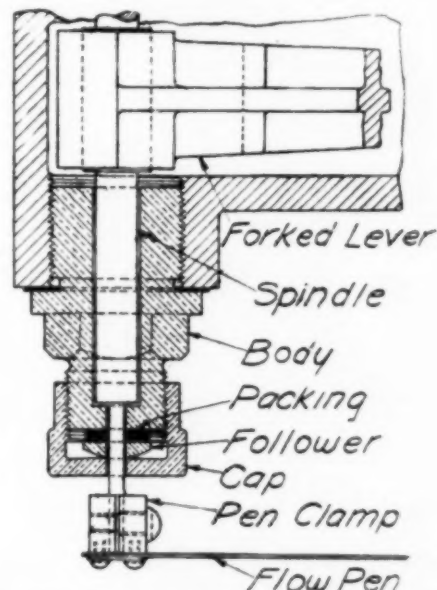


FIG. 4—DETAIL OF PRESSURE TIGHT BEARING

100 per cent, or maximum capacity of the meter. The same condition holds true for Venturi tubes, Pitot tubes, multiple-hole nozzles, etc., as means for producing a pressure difference, but the large area of the bell which is effective at the low rates of flow, together with the absence of friction, gives a great degree of accuracy over a wide range of flow.

The spindle, which is given a rotative motion by the movement of the bell, has ends of small diameter which pass through a pressure-tight bearing, shown in detail in Fig. 4. This pressure tight bearing should not be confused with a stuffing box or cup leather packing, for it obviates the objectionable features of both of these.

All danger of spilling mercury in shipping and installing is obviated by having the mercury hermetically sealed in the reservoir by means of a lid and gaskets held in place by a wing nut.

Another valuable feature of this meter is the automatic shut-off which prevents blowing out of the mercury or other damage when either of the pressures is excessive, due to an abnormally high rate of flow, improper opening of valve, or even the breaking of one of the connecting pipes.

Two recording thermometers can be used equally well in connection with an orifice feed water meter, such as Type C2, where one thermometer records the temperature of water entering the economizer and the other records the temperature leaving the economizer. A chart graduated from 100 deg. Fahr. to 350 deg. Fahr. is supplied for this purpose. This meter can be provided either with or without an integrator.

Many weighed water calibrations have been made on these meters measuring both steam and water at intervals over considerable periods of time. The great majority of such calibrations have shown an agreement between the weight and meter readings within 1 per cent. In but very few cases have the differences exceeded 2 per cent.

Digest of Electrochemical U. S. Patents

PRIOR TO 1903

Arranged according to subject-matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

Aqueous Bath Cathodes

(Continued)

633,315, Sept. 19, 1899, Charles W. Heergeist of Philadelphia, Pa., assignor of one-half to Charlton H. Royal of same place.

Relates to making signs and the like by electrodeposition, the letters or characters being in intaglio. Upon a suitable smooth metal plate are secured letters or characters in reverse order, by wax or other adhesive. The surfaces of the letters and of the metal plate are prepared so that the deposit may be readily stripped therefrom. After the deposit is completed, it is stripped from the plate, the letters or characters are then removed from the deposit, and the face of the deposit dressed to remove sharp edges, etc.

634,523, Oct. 10, 1899, George Epp of Vienna, Austria-Hungary.

Relates to the production of patterned metal foils which are mounted upon paper, linen, leather, etc. A German silver matrice, suitably engraved, has its surface treated by immersion in a solution of sulfantimonate of sodium for a few seconds, which produces a surface from which the deposit may be readily stripped. The treated matrice is now connected as cathode in a nickel plating solution, which shows a slightly acidulated reaction, and a current at from two to three volts passed through for two or three minutes. The nickel deposit is then reinforced by a copper deposit, and the mounting of paper, linen, etc., then applied. It is then stripped from the matrix.

655,344, Aug. 7, 1900, James Hargreaves of Widnes, England.

Relates to cathodes for electrolytic cells, and is a division of an earlier application. The cathode consists of woven wire cloth which has been rolled so as to flatten out its prominent points such as the cross wires. The cathode thus flattened is secured to the diaphragm as in the well known Hargreaves-Bird cell. It is said that the new cathode effects a reduction in the resistance while increasing the electric osmose and decreasing the Grahamic osmose, resulting in a reduction in the undecomposed electrolyte passing into the cathode space of the cell.

660,416, Oct. 23, 1900, Sherard Osborn Cowper-Coles of London, England, assignor of one-half to The Reflector Syndicate, Limited of same place.

Relates to the manufacture of reflectors, and consists in using a highly polished truly-shaped cathode of speculum metal. The speculum metal may be composed of fifteen parts tin, thirty-two parts copper, and one part arsenic; or it may consist of one part tin and two parts copper. The molten alloy is carefully poured into an iron mold, and after cooling, is removed and dressed as desired, and polished. Its surface is now coated with a thin film of beeswax dissolved in a suitable solvent, to facilitate the easy removal of the deposit. The body of the reflector is then deposited and is reinforced by a deposit of copper. It is then removed from the cathode, and the reflecting surface is coated with a deposit of platinum, palladium, or chromium. The platinum bath consists of freshly precipitated double chlorid of platinum and ammonium, dissolved in a boiling concentrated neutral solution of citrate of sodium, and should con-

tain about $1\frac{1}{2}$ ounces of platinum per gallon. The current should have a density of about 3 amp. per square foot of cathode surface, and the difference of potential between the terminals of the depositing cell should be about three-quarters of a volt.

683,263, Sept. 24, 1901, Elmer G. Elliott and Valentine Kishner of Perth Amboy, N. J.

Relates to the making of starter sheets for use in the electrorefining of copper. A base cathode of either sheet lead or sheet copper is provided with a "scratch-groove" around its edge or on its surface near the edge, and copper deposited over the entire base cathode. After a thickness of about $1/32$ of an inch has been deposited, the deposit is raised at one end and torn off, the scratch-groove having the property of preventing a continuously uniform deposit, and permitting the easy tearing of the metal along the scratch, and separating it from the base. The sheet thus separated may be used as a cathode of pure metal for the deposition of copper in electrorefining.

684,291, Oct. 8, 1901, William A. McCoy of Perth Amboy, N. J.

Relates to the making of starter sheets for use in the electrorefining of copper. A base cathode of sheet copper is provided near its bottom and side edges with a row of depressions or perforations, close together, and filled with insulating material. The deposit of copper forms upon the plate and upon the narrow portions of metal between the depressions or perforations, the deposit upon the narrow portions being readily torn thereby permitting the easy removal of the deposited sheet, which is used as a cathode for the deposition of metal in the refining vats.

Obituary

Harry Clary Jones, professor of physical chemistry at Johns Hopkins University, died suddenly on April 9 at his home in Baltimore, Md. He was born in New London, Md., on Nov. 11, 1865, and graduated from Johns Hopkins in 1889. Later he studied at the Universities of Leipzig, Amsterdam and Stockholm. In 1895 he became an instructor in physical chemistry at Johns Hopkins, in 1904 a full professor. He was one of the staunchest defenders of the electrolytic dissociation theory and a prolific and brilliant author and lecturer.

Personal

Col. D. C. Jackling is cruising in South American waters in his yacht the Cypress. He and his guests are understood to have in view the expediency of taking over options upon large Bolivian tin properties.

Mr. B. T. Colley, smelter superintendent of the Braden Copper Co., has returned to Chile from the States.

Dr. L. H. Baekeland gave a talk before the Patria Club in the Seventh Regiment Armory on April 7 on our needs for chemical preparedness.

Mr. C. A. Lunn, director of the flotation oils department of the General Naval Stores Co., New York, is making a trip through Colorado, Utah, Idaho, Montana and Nevada in the interest of flotation oils. Mr. Lunn has been engaged for several years in developing oils for flotation work.

Mr. George E. Dyck has recently been appointed industrial chemist, Chicago Bureau of Waste, and will have charge of the municipal garbage reduction works. He was graduated in chemical engineering from Kiel University, Germany, in 1890 and for a year following was a lieutenant in the German navy. After coming to this country in 1891 he was employed by Morris

& Company, St. Joseph, Mo., leaving them in 1897 to become chief chemist of the National Provisioner Laboratory in New York. From 1899 until 1902 he superintended the manufacture of fertilizer and sulphuric acid for the Virginia & Carolina Chemical Company of Memphis, Tenn. For two years thereafter he was superintendent of the Chicago Reduction Company and from 1904 to 1907 was with Sulzberger & Sons Company as department manager of fats, oils and fertilizer. Since that time he has been the head of the Agricultural Laboratory in Chicago except during the last half year, when he was an instructor in the Siebel Institute of Technology.

Mr. R. J. Wysor, formerly chief chemist, has been appointed superintendent of the blast-furnace department of the Bethlehem Steel Co., South Bethlehem, Pa.

Dr. Walter F. Rittman has severed his connection with the Bureau of Mines and will devote his time to the Rittman Process Co., of which he is the vice-president. Mr. E. W. Dean has succeeded Dr. Rittman at the Bureau of Mines in Pittsburgh.

Mr. Thomas W. Pritchard has severed his connections with Messrs. E. B. Badger & Sons Co. in order to become manager of sales for the Niagara Alkali Co. and the Electro Bleaching Gas Co., with headquarters at 18 East 41st Street, New York City.

Mr. G. C. Riddell has resigned as superintendent of the American Smelting & Refining Co.'s lead plant at Helena, Mont., and will become superintendent of the Burma Corporation smelter, Numta, Burma, India.

Mr. Charles F. Rand sailed for Cuba on March 26 with a party of other gentlemen, mostly officials and engineers of the Bethlehem Steel Co. The Mayari and other properties now owned by the Bethlehem Steel Co. will be visited.

Mr. William G. Schneider, manager of the smelting plant of the Magnolia Metal Co. at Matawan, N. J., has resigned due to poor health and will devote the next month to recuperation.

Mr. W. J. Richards, president of the Reading Coal & Iron Company, announces the appointment of George S. Clemens of Pottsville as consulting engineer of the company, a new position. Charles Enzian, formerly employed by the Government in the Department of Mines, has been appointed mining engineer of the Shenandoah and Mahanoy division.

Industrial Notes

Potash.—The Potash Recovery Company, a California corporation formed for the purpose of manufacturing potash and other fertilizing chemicals from distillery waste under a patented process, has been permitted by Commissioner H. L. Carnahan to issue 500 shares of its common stock to H. O. Chute and John D. Spreckels, Jr., in exchange for an exclusive license to use the processes and apparatus covered by the patent and an option for the use of the waste products of Mason Malt Whiskey Distilling Company at Sausalito for a period of five years. It is estimated that \$40,000 or \$50,000 will be required to build a plant and install machinery.

The Hargreaves-Bird electrolytic alkali process, according to the *Mining Magazine*, after many years of vicissitude, followed by a drastic reconstruction of the company and change of control, is now being worked at a profit, at Middlewich, Cheshire.

Italy Considering Further Water Power Development.—Italy's coal supply comes mostly from England, and the shutting off of some of this supply and the

difficulty of obtaining shipments have had the effect of arousing Italy to the necessity of further water power development. A series of royal decrees has been issued creating subsidies and other governmental help for the installation and development of more hydroelectric plants. Italy already has a large hydroelectric development, but she plans to free herself from industrial dependence on any other country for power.

The Braden Copper Co., Chile, is planning an increase in its milling facilities to 10,000 tons daily capacity.

Coating Aluminium.—According to *The Engineer* (London) of Feb. 18, a French metallurgist proposes to give aluminium a coating that will take a high polish by successive baths of boiling lye, cyanide, and hydrochloric acid containing ferrous chloride, followed by nickel-plating. The plating is said to be so perfect that the metal can be rolled into plates, drawn into wires, or hammered into any shape without in any way injuring the film of nickel.

The Central Scientific Co. of Chicago will show at the Urbana, Ill., meeting of the American Chemical Society a new line of DeKhotinshy electrically heated and regulated water baths, drying ovens, incubators, etc.

The Bristol Company, Waterbury, Conn., has issued a pamphlet describing its long-distance electric transmitting and recording system for remote records of pressure, liquid level, temperature and motion.

Compressed Air Meter.—The New Jersey Meter Co., Plainfield, N. J., has issued a bulletin describing its compressed air meter for registering the consumption of tools, machines or apparatus run by air. This meter is known as the toll-ometer, and shows direct the flow of air in a pipe or hose in cubic feet of free air per minute.

The W. S. Rockwell Co., 50 Church Street, New York City, has issued a new bulletin (No. 30) describing furnaces and furnace operations from the standpoint of automatic handling. The bulletin contains a discussion of the problems attending the development of automatic heating.

Determination of Size of Filter Plates.—Messrs. D. R. Sperry & Co., Batavia, Ill., manufacturers of filter-presses, have issued a little circular describing how to quickly determine what size of filter plate to use if the total filtering area is given. By the use of a chart it can be quickly found what size of filter plate should be used to obtain minimum expense and what number of plates in that size are required.

William Gaertner & Co., Chicago, Ill., have issued catalog C, describing Scientia calorimeters and other apparatus for fuel testing. Included in this catalog are descriptions of water-jacket calorimeters, calorimeters for specific heat of solids and liquids, Waterman calorimeter, Bunsen ice calorimeter, and other apparatus including the new improved Scientia gas calorimeter.

The Raymond Bros. Impact Pulverizer Co., Chicago, Ill., has issued a new catalog, No. 12, describing grinding, pulverizing and air-separating machinery. The catalog, which is nicely illustrated, includes a description of a new smaller size pulverizer which uses 5 hp. and produces from 200 to 1000 lb. per hour, depending on the material to be pulverized.

The American Synthetic Dyes, Inc., announce the removal of their general offices to the Adams Express Building, 61 Broadway, New York.

Foreign Trade Under the New Tariff.—Secretary Redfield has transmitted to the Senate a detailed statement of the results of the Underwood-Simmons tariff act as reflected in the foreign trade of the country up to the time the war started in Europe. The statement was prepared in the Bureau of Foreign and Domestic Commerce in response to a Senate resolution of Jan. 17, 1916, calling upon the Secretary of Commerce for information in regard to trade under the present tariff. The report is printed as Senate Document No. 366. It contains information regarding the value of imports, exports, and import duties under the present and the two preceding tariff acts; the value of imports, compared with the value of domestic production, and the expenditure for wages in each industry before the outbreak of the European war; and the imports and exports of leading manufacturing countries during recent years.

The Vanadium-Alloys Steel Company of Pittsburgh, Pa., has just issued two folders descriptive of the Vasco Choice and Vasco Non-shrinkable grades of tool steel.

Japanese Regulating the Dyestuff Market.—According to *Commerce Reports* a number of well-known dye merchants of Tokyo, Osaka, and Nagoya have formed a dyestuffs trust, called the Kokuryu Kai, with offices at Osaka, with the object of preventing speculative transactions by amateurs and of regulating the market when the inevitable slump comes, either at the end of the war or earlier. The production of aniline dyes is rapidly increasing. The manufacturers still keep secret the monthly output of their plants, but, according to the *Japan Mail* of Feb. 25, 1916, the monthly production of aniline oil at different works now exceeds 60,000 lb. (a rate of 360 short tons per annum).

Standard Density and Volumetric Tables.—A revised edition of its Circular No. 19 on "Standard Density and Volumetric Tables" has just been issued by the United States Bureau of Standards. It contains tables for use in measurements of density and volume of such liquids as water, alcohol, sugar solutions, petroleum oils, etc., and special tables for use in the calibration of glass volumetric apparatus and hydrometers. In the new edition the tables have been rearranged and several new ones added. Copies may be obtained free by persons interested upon application to the Bureau of Standards, Washington, D. C.

The C. F. Burgess Laboratories, chemical engineers, located at Madison, Wis., have increased their capitalization to \$100,000. The officers are C. F. Burgess, president; Vrooman Mason, vice-president; W. B. Schulte, secretary and treasurer. The Chicago office is located in the Harris Trust Building. Duncan Keith, manager.

Magnetic and Mechanical Properties of Steel.—The Bureau of Standards has just issued a bulletin (Scientific Paper No. 272) on the "Correlation of the Magnetic and Mechanical Properties of Steel," by Charles W. Burrows. The paper is a review of the work done in correlating the magnetic and mechanical properties of steel. Among mechanical properties that have been studied in connection with the magnetic characteristics are hardness, toughness, elasticity, tensile strength and resistance to repeated stresses.

New Chemistry Building for Throop College.—The contract has been let for a new chemistry building for Throop College of Technology, Pasadena, Cal., to cost \$60,000. It is expected that the building will be complete in time for the opening of the fall term this year.

The building will contain a research laboratory of physical chemistry to be under the direction of Dr. A. A. Noyes, who will spend half of each year at Throop College and half at the Massachusetts Institute of Technology.

New Building Construction at University of California.—University building bonds of the value of \$1,800,000 have been approved by the people of California for new buildings at the University of California. The money will be subdivided as follows: \$700,000 for Benjamin Ide Wheeler Hall, a classroom with capacity of 3500; \$525,000 for completion of the library, the present part of which cost \$840,000; \$350,000 for a second group of agricultural buildings; \$160,000 for the first unit of a group of permanent buildings for chemistry; 70,000 for new unit for heating and power plant, the balance for furnishings and equipment.

The University of Kansas, chemical engineers, held a joint meeting with the Kansas City Section of the American Chemical Society on March 31 at the University, in Lawrence, Kan. Among the speakers were Prof. W. A. Whitaker, who contributed opening remarks; Mr. George Belchic, who spoke on "Flotation"; Mr. E. H. Burtch, who spoke on "Zinc Smelting"; Dr. Roy Cross, who spoke on the cracking of petroleum, and Mr. C. A. Wright, who spoke on losses and problems in the Joplin district.

Book Reviews

Coal and Coke. By Frederick H. Wagner, M. E. Octavo (15 x 23 cm.), 431 pages, 136 illustrations. Price, \$4.00 (17/). New York: McGraw-Hill Book Company, Inc.

Part I, treating of coal, is only one-fourth of the book, and is principally a short treatise on the raw material of coke manufacture. It is a well-written but brief summary of the subject.

Part II, treating of coke, is the other three-quarters of the book. It is a first-class up-to-date discussion, in great detail, of the present methods of manufacturing coke from bituminous coal, valuable not only for the student but for the scientist and the practical man in the business.

We do not see any mention of "peat coke," which is successfully made in Europe. The book is otherwise very complete and satisfactory.

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Applied Electrochemistry and Welding. Part I: Applied Electrochemistry, by Chas. F. Burgess, 83 pages. Part II: Welding, by Geo. W. Cravens, 132 pages. Well illustrated; price \$1.50. Chicago: American Technical Society.

These are in reality two separate books, bound together so as to make one respectable volume. Professor Burgess discusses electrolysis, electroplating, decomposition of salt solutions, fused electrolytes, electric furnaces, and electric discharge in gases. Although very limited as to space, yet there is a large amount of very useful and well-chosen information, enlivened by many collateral remarks, compressed into Part I. Almost any electrochemist will find something new in it to interest him.

The treatment of welding, by Mr. Cravens, is comprehensive and practical. A large part of it is electric welding, but the other methods are properly described. Numerous fine illustrations are shown up well by the thick calendered paper used.

The book as a whole is a useful and very creditable work.